ALBERTA FORAGE MANUAL

2nd edition

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Arvid Aasen & Myron Bjorge

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Introduction

Tame forage crops generally include annual and perennial legumes and grasses consumed by grazing livestock or utilized as stored feed. These forage species, especially the perennial legumes and grasses, make a valuable contribution towards supplying livestock feed and conserving soil and water resources. Forage crops add to the diversity and beauty of agricultural and urban landscapes, as well as contribute to the carbon cycle as a carbon sink.

This manual is meant to be used as a guide to forage production as it applies to Alberta. Information is presented to assist producers in the production and use of forages. Plant growth and regrowth are affected by the soil climatic areas where they are grown, and forage species and management may differ from one area to another, so this manual identifies the areas of best adaptation of these crops within Alberta.

Perennial legumes and grasses and annual forages are described as to their growth and development, competitiveness and persistence, yield and quality, limitations and use as hay, silage and pasture.

Good perennial forage establishment is needed to produce a productive crop. Once the crop is established, proper management and fertility are needed to sustain a productive forage stand. This manual has a section on rejuvenation as hay and pasture stands may become unproductive, and rejuvenating may be needed for them to become productive again.

The forage quality of harvested and stored forage can be very variable. The quality difference has more to do with plant maturity and harvest and storage management than with species. At the time forage is cut in the field, the quality is as high as it will be because quality levels decrease from that point until the forage is consumed by livestock. How the forage is handled and stored will determine how much the quality decreases.

Grazing utilizes forage without the harvesting and quality losses. Good pasture management is important to maximize livestock production and forage yield. Grazing systems, including winter grazing, are included in the manual.

Sections dealing with diseases and insects injurious to forage crops are included in the manual as significant losses can occur in hay and pasture crops due to these influences. These sections include colour images to assist with the identification of the disease or insect causing damage.

FORAGE ADAPTATION

Forage Adaptation

Climate and soil conditions determine where forages can be grown. There is a species and variety that is the best suited forage crop for most sites. This section includes information on the characteristics of the forage species adapted to Alberta.

Alberta is an ecologically diverse province with different soil types, weather patterns and topography. The soil climatic areas are classified on the basis of the major climatic and biological differences where forages are grown in the province (Figure 1). Factors such as precipitation (Figure 2) and soil classification (Figure 3) are just two of the elements taken into consideration when the soil climatic area map was developed.

Many factors should be considered when determining what forages to produce. Regional adaptation, site specific adaptation, the intended use of the crop and desired crop rotation or longevity all enter into the decision as to which species to grow. The intended use will affect management, including such factors as percentage of legume to grow, stage of harvest and, in the case of pasture, what forages are grazing tolerant.

FIGURE 1
Major soil climatic areas of Alberta

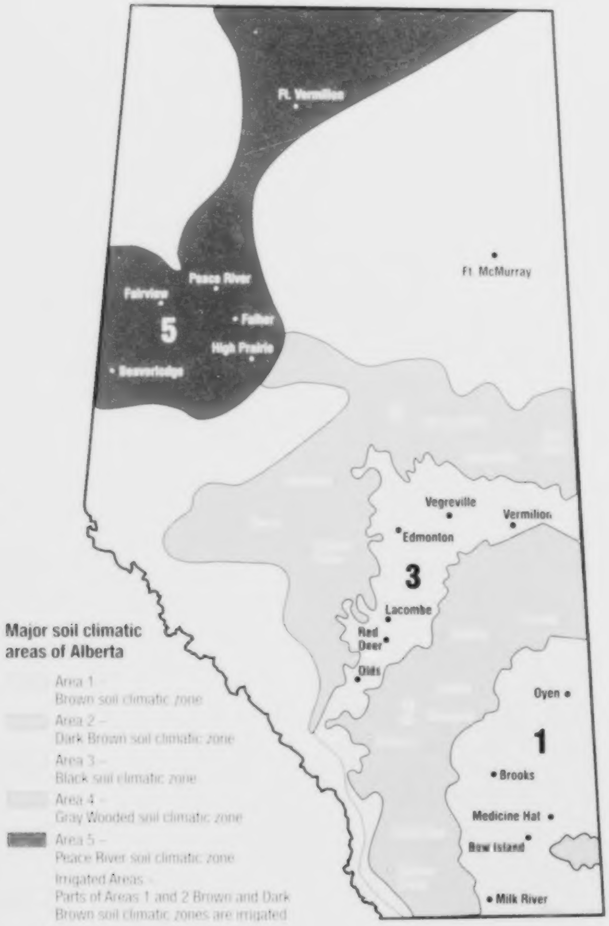
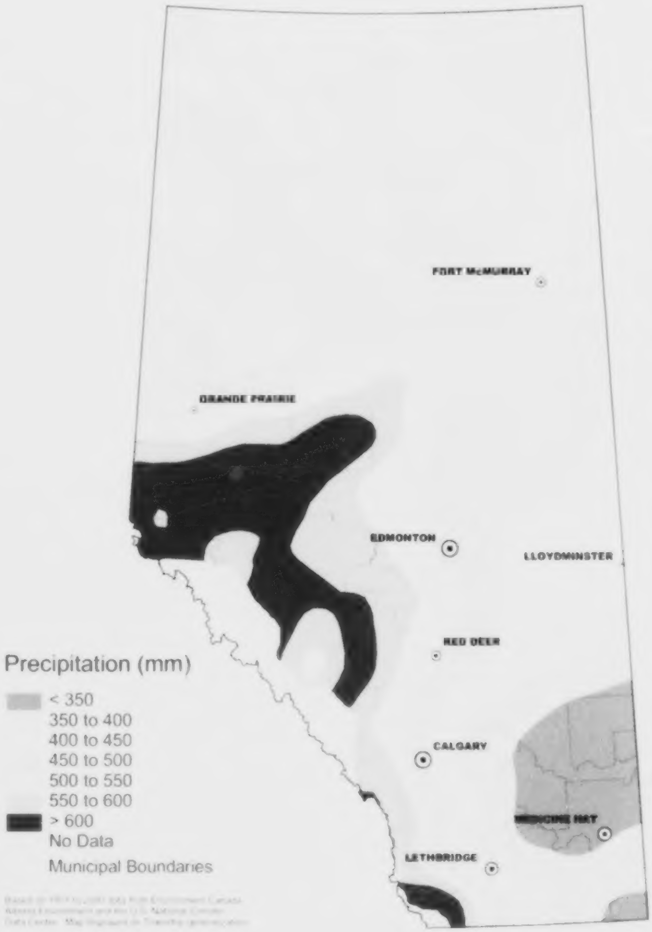
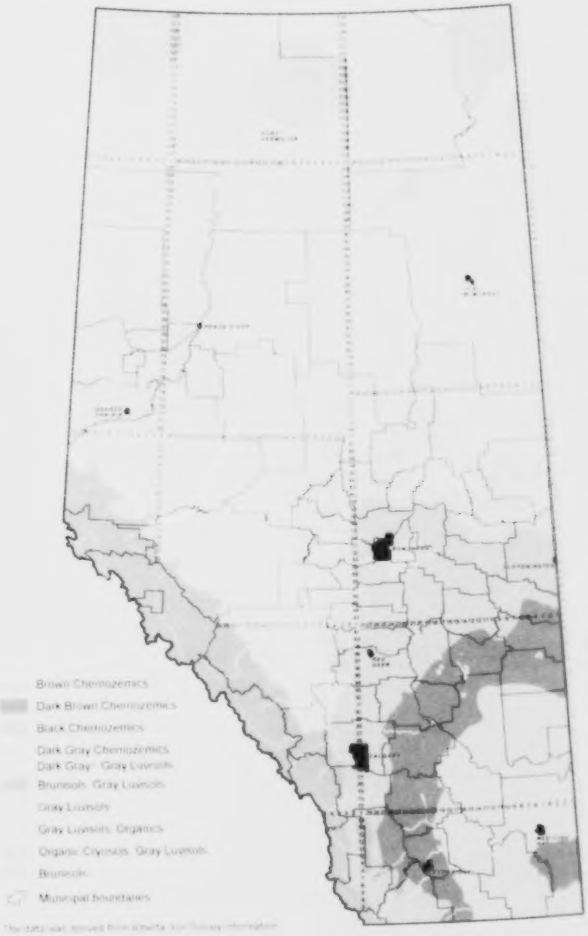

Ft. Vermilion
Ft. McMurray
Peace River
Fairview
5
Falher
High Prairie
Beaverlodge
Vegreville
Vermilion
Edmonton
3
Lacombe
Red Deer
Olds
Oyen
1
Brooks
Medicine Hat
Bow Island
Milk River
Major soil climatic areas of Alberta
Area 1 – Brown soil climatic zone
Area 2 – Dark Brown soil climatic zone
Area 3 – Black soil climatic zone
Area 4 – Gray Wooded soil climatic zone
Area 5 – Peace River soil climatic zone
Irrigated Areas – Parts of Areas 1 and 2 Brown and Dark Brown soil climatic zones are irrigated

FIGURE 2
Annual total precipitation in Alberta (1971 to 2000)


FORT McMURRAY
GRANDE PRAIRIE
EDMONTON
LLOYDMINSTER
RED DEER
CALGARY
MEDICINE HAT
LETHBRIDGE
Precipitation (mm)
< 350
350 to 400
400 to 450
450 to 500
500 to 550
550 to 600
> 600
No Data
Municipal Boundaries

Short summers and periodic drought are important factors affecting crop production in Alberta. The frost-free period varies from about 120 days in parts of southern Alberta to 80 days or less in agriculture zones further north and west where elevation and/or latitude are greater. Summer days are long, making for good rates of growth. Reduced growth rate due to drought may occur at any time during the growing season. Alberta normally does not have a summer slump in growth rate from excessive heat, as occurs in more southern latitudes. Winters are very cold so that forages must be very hardy. Snow cover is important to insulate plant crowns and roots from the cold.

FIGURE 3
Soil groups of Alberta



The data was derived from Alberta Soil Survey information

Adaptation

Producers should first determine what species to grow by considering regional adaptation followed by site adaptation. Regional forage testing is useful for determining suitable forage species, varieties and expected yields for these crops on normal soils. A regionally adapted forage with good site tolerance will yield better than one with poor regional adaptation and excellent site tolerance.

When using Table 1, which is a summary of forage species adaptation in Alberta, consider areas of adaptation of the species before considering specific species characteristics and tolerances. Forages adapted to the region and site may affect what uses and rotations are practical.

Area 1 is the driest forage production zone in Alberta with annual precipitation (Figure 2) being approximately 300 to 350 mm (12 - 14 in.). Forage crops grown here need to be adapted to low soil moisture. Drought is also a major factor in forage crop establishment, with establishment failure being common. This area has a high rate of evapotranspiration, which causes a moisture deficit. Wind erosion is a hazard, making forage use important for soil stabilization. Forages require very good winter hardiness. Soil salinity can be a problem in some areas of the Brown soil zone.

The most dominant vegetation is presently native rangeland. Well managed native range is desirable and practical on a major portion of the land in Area 1. There is a place for introduced tame forages on cultivated land, although their soil drying effect needs to be considered when rotating with annual crops.

Compared to native prairie, tame forages may be more productive, tolerate heavier use and can be utilized at more critical times. An example would be to graze crested wheatgrass in early spring, native rangeland in mid-season and Russian wildrye grass in the fall. Grazing seeded tame forages in the spring and fall compliments the native pastures. In a study near Manyberries, Alberta, Smoliak and Dormaar found that over a 25-year period unfertilized crested wheat grass and Russian wild rye, respectively yielded 113 per cent and 47 per cent more than native range.

Forage crop choices are limited. Of the tame forages, crested wheatgrass is the most commonly used grass and alfalfa the most commonly used legume. Alfalfa varieties need to be hardy, with dryland types being most commonly used. Other commonly used tame forages include Russian wildrye, Altai wildrye and some of the wheatgrasses. See Table 1 for adaptable species for Area 1.

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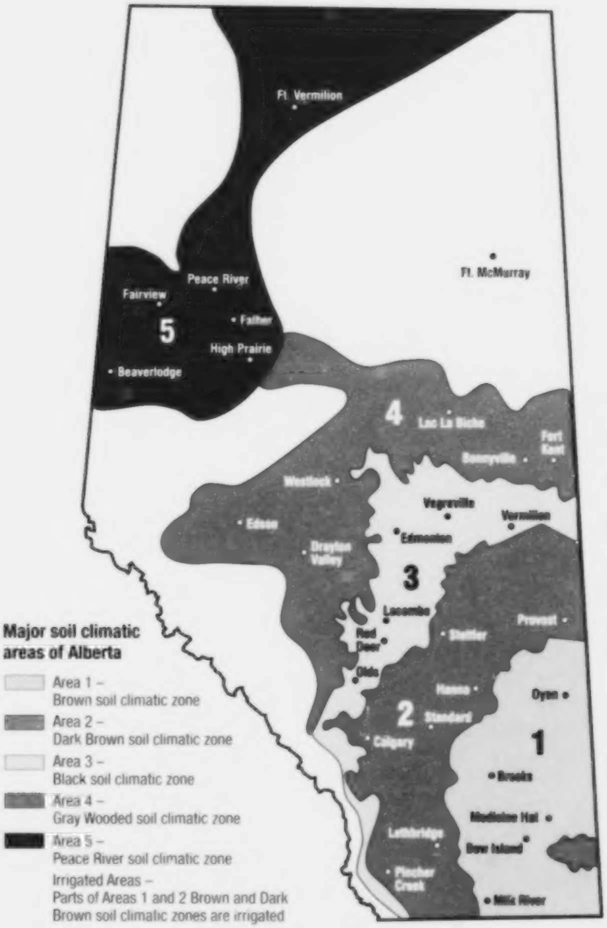
Ft. Vermilion
Ft. McMurray
Peace River
Fairview
5
Falher
High Prairie
Beaverlodge
4
Lac La Biche
Fort Kent
Bonnyville
Westlock
Vegreville
Vermilion
Edson
Edmonton
Drayton Valley
3
Lacombe
Provost
Red Deer
Stettler
Olds
Hanna
Oyen
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Standard
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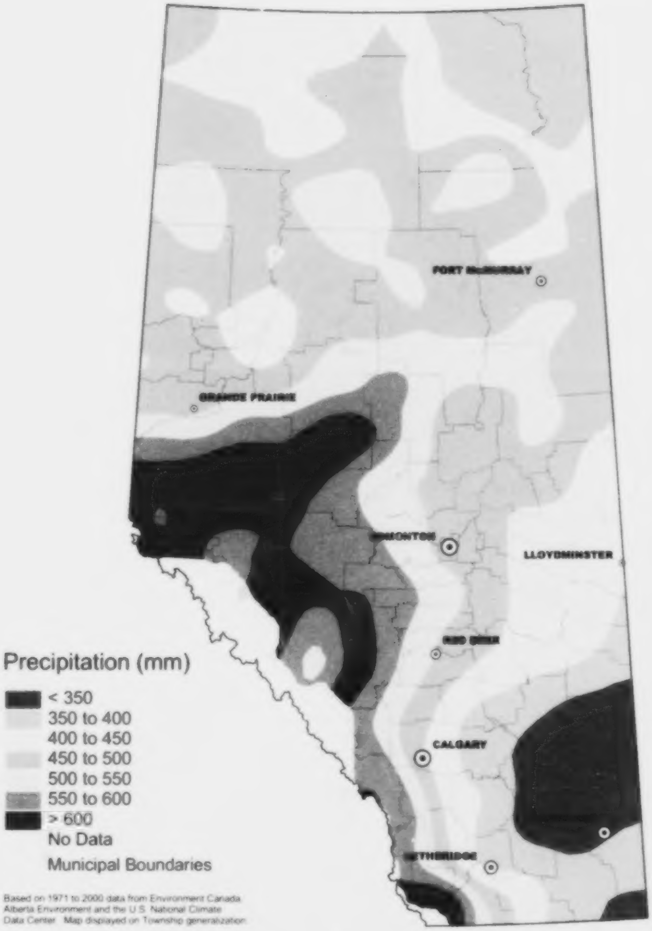
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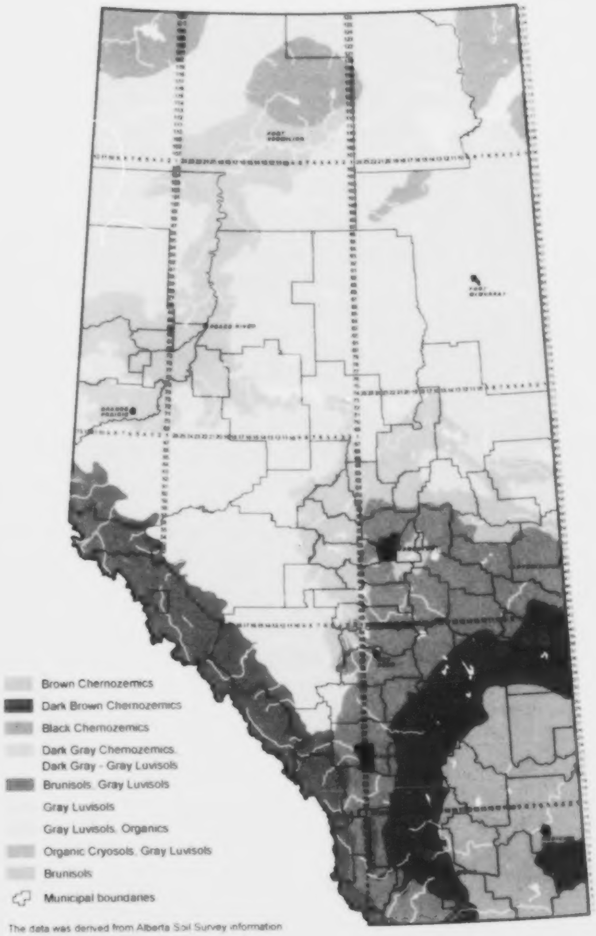

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AREA 1 – BROWN SOIL CLIMATIC ZONE

Area 1 is the driest forage production zone in Alberta with annual precipitation (Figure 2) being approximately 300 to 350 mm (12 - 14 in.). Forage crops grown here need to be adapted to low soil moisture. Drought is also a major factor in forage crop establishment, with establishment failure being common. This area has a high rate of evapotranspiration, which causes a moisture deficit. Wind erosion is a hazard, making forage use important for soil stabilization. Forages require very good winter hardiness. Soil salinity can be a problem in some areas of the Brown soil zone.

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TABLE 1
Summary of tame species adaptation in Alberta[1]

Species	Areas of Adaptation	Drought Tolerance	Hardiness	Longevity	Tolerance of Excess Soil Moisture	Tolerance of Acidity	Tolerance of Salinity	Suitability for Hay	Tolerance to Grazing	Pasture Regrowth Rate	Bloat-Causing
Alfalfa	all	exc	fair to exc	fair to good	poor	poor	fair	exc	fair to good	fair to exc	yes
Birdsfoot Trefoil	3, 4, 5	fair	poor	poor	good	good	good	fair	good	good	no
Cicer Milkvetch	2, 3, 4, 5, Irr	good	exc	good	fair	fair	fair	fair	good	fair	no
Alsike Clover	3, 4, 5	poor	good	fair	good	good	poor	good	good	good	yes
Kura Clover	3, 4, 5	fair	good	good	fair	fair	poor	poor	exc	exc	yes
Red Clover	3, 4, 5	fair	fair to good	poor	fair	good	poor	good	good	exc	yes
Sweetclover	1, 2, 3, 4, 5	exc	exc	biennial	poor	poor	good	good	fair	poor	yes
White Clover	3, 4, 5, Irr	poor	poor to fair	poor to fair	good	good	poor	poor	exc	exc	yes
Sainfoin	2, Irr	good	good	fair	poor	poor	poor	good	poor	poor	no
Meadow Bromegrass	2, 3, 4, 5, Irr	good	good	good	poor	fair	fair	good	exc	exc	
Hybrid Bromegrass	2, 3 ,4, 5, Irr	good	good	good	poor	fair	good	exc	good	good	
Smooth Bromegrass	2, 3, 4, 5, Irr	good	exc	exc	fair	fair	good	exc	good	poor	
Creeping Red Fescue	3, 4, 5	fair	exc	exc	good	exc	good	poor	good	exc	
Meadow Fescue	3, 4, 5, Irr	fair	fair	fair	good	good	good	good	good	good	
Tall Fescue	3, 4, 5, Irr	fair	fair	fair	good	exc	good	good	good	exc	
Creeping Foxtail	3, 4, 5	poor	exc	exc	exc	good	fair	fair	exc	good	
Meadow Foxtail	3, 4, 5	poor	exc	exc	exc	good	poor	fair	exc	good	
Kentucky Bluegrass	3, 4, 5, Irr	good	exc	exc	good	good	poor	poor	exc	exc	
Orchardgrass	3, 4, 5, Irr	fair	fair	fair to good	fair	fair	fair	good	exc	exc	
Reed Canarygrass	1, 2, 3, 4, 5	good	good	exc	exc	exc	good	good	good	good	
Italian Ryegrass	3, 4, 5, Irr	poor	poor	poor	good	good	fair	fair to good	exc	exc	
Perennial Ryegrass	3, 4, 5, Irr	poor	poor	poor	good	good	fair	poor	exc	exc	
Timothy	3, 4, 5, Irr	poor	exc	good	good	good	poor	exc	fair	poor	
Crested Wheatgrass	1, 2	exc	exc	exc	poor	fair	good	fair to good	exc	poor	
Intermediate Wheatgrass	2, 3, 4, 5, Irr	good	good	fair	fair	poor	good	exc	fair	fair	

Species	Areas of Adaptation	Drought Tolerance	Hardiness	Longevity	Tolerance of Excess Soil Moisture	Tolerance of Acidity	Tolerance of Salinity	Suitability for Hay	Tolerance to Grazing	Pasture Regrowth Rate	Bloat-Causing
Northern Wheatgrass	1, 2, 3, 4, 5	exc	exc	exc	fair	fair	good	poor to fair	fair	fair	
Slender Wheatgrass	All	good	exc	fair	fair	fair	exc	good	fair	fair	
Tall Wheatgrass	2, 3, Irr	good	good	good	good	poor	exc	good	fair	poor	
Western Wheatgrass	1, 2, 3, 4, 5	exc	exc	exc	good	fair	exc	good	good	fair	
Altai Wildrye	1, 2	exc	exc	exc	fair	fair	exc	poor	good	fair	
Dahurian Wildrye	1, 2, 3, 4, 5	good	good	poor	fair	fair	exc	good	good	good	
Russian Wildrye	1,2	exc	exc	exc	fair	fair	exc	poor	good	fair	

Notes

1 Ratings are subjective and approximate. Information is from many sources, and tolerances are approximate.

2. **Acidity**
Poor = sensitive to acidity
Excellent = tolerant to below pH 5.0

3. **Salinity**
Poor = Sensitive to low salt, below EC (dS/m) of 4
Excellent = tolerant up to EC (dS/m) of 12 - 16

4. Varieties may be selected for greater environmental tolerances.

5. Adaptability in the field depends on many factors.

6. Pasture regrowth rate indicates time to regrow rather than amount of regrowth.

7. Alfalfa and red clover varieties vary in hardiness and longevity. Kura clover adaptation in Alberta is not well documented. Birdsfoot trefoil is a poor competitor and often goes out of a stand prematurely. Sainfoin is affected by root and crown disease, especially in more moist areas, and often goes out of the stand prematurely.

8. The area of adaptation also depends on the site.
For example, reed canarygrass and the foxtails are only adapted to the wet sites in Areas 1 and 2. Some species have variable hardiness, depending on the variety, which is particularity the case for alfalfa, tall fescue, orchardgrass and perennial ryegrass. Grasses that are rated as having excellent longevity are more or less permanent, provided the stand is well managed and growing on a site well suited to its adaptation.

When deciding on a species, select for the area of adaptation and then select the species with the characteristics and tolerances needed for the site and intended use of the forage crop. See the species sections for more detailed information on a species and adaptation.

AREA 2 –
DARK BROWN SOIL CLIMATIC ZONE

Better moisture in Area 2 allows for greater use, and a wider choice, of forage crops. Annual precipitation (Figure 2) in the Brown soil zone is from approximately 350 to 450 mm (14 - 18 in.). Forages require tolerance to long-term drought although there is generally sufficient moisture to support a tame forage crop. Excellent winter hardiness is required. Wind erosion is a hazard, making forage use important for soil stabilization, especially in southern Alberta. Soil salinity can be a problem in some areas of the Dark Brown soil zone.

The bromegrasses are commonly used in the more moist parts of the region. Crested wheatgrass and intermediate wheatgrass are also commonly grown grasses. Dryland alfalfa is well adapted. Altai wild ryegrass, Russian wild ryegrass and some of the other wheatgrasses are commonly used in the drier areas of Area 2. See Table 1 for adaptable species.

AREA 3 –
BLACK SOIL CLIMATIC ZONE

Annual precipitation (Figure 2) in Area 3 is from approximately 400 to 550 mm (16 - 22 in.). Short-term and occasional long-term droughts occur, but precipitation is generally not a limiting factor in forage production or continuous cropping of annual crops. Forage production responds to the higher moisture conditions and higher rates of fertilizers can be used to increase forage production in Area 3. Cropping rotations utilizing legumes and grasses can be used to effectively increase or maintain the organic matter in the soils.

Smooth bromegrass, timothy and alfalfa are the most commonly used species for hay production. Meadow bromegrass, orchardgrass and alfalfa are frequently used for pastures. Clovers (red and alsike) are used in the more moist parts of the region. Species adapted to severe drought, such as crested wheatgrass, are less adapted to Area 3. See Table 1 for adaptable species.

AREA 4 –
GRAY WOODED SOIL CLIMATIC ZONE

Area 4 is the Gray Wooded soils zone in central and north central Alberta, excluding the Peace River Area.

Annual precipitation (Figure 2) in Area 4 varies from about 450 to 600 mm or more (18 - 23 in.). Short-term and occasionally long-term droughts can occur. Bromegrasses and alfalfa are important drought tolerant species.

Gray Wooded soils are often low in organic matter, and forage establishment can be a problem if crusting occurs. The use of forages is important in increasing the organic matter and improving these soils. As the growing season is short, forage makes up a large portion of the total cultivated acreage.

Commonly used forages include timothy, bromegrasses, creeping red fescue, alsike and red clover and alfalfa. Orchardgrass is frequently grown in the more southern parts of Area 4. Kentucky bluegrass and small white clover commonly volunteer on older pastures. See Table 1 for adaptable species.

AREA 5 – PEACE RIVER SOIL CLIMATIC ZONE

Area 5 is the Gray Wooded and Black soils in Northern Alberta lying north and west of Lesser Slave Lake and High Prairie including the Peace River area. The Black and Dark Gray soils in this area are productive and respond to good management. The Gray Wooded soils of Area 5 are similar to those in Area 4, but generally receive less growing season precipitation.

Annual precipitation varies from about 400 to 550 mm (16 - 22 in.) or more, but in many areas the rate of evapotranspiration is low. Short-term drought is common, and long-term drought occurs. The growing season in Area 5 is relatively short, but the long days during the growing season help to compensate for the shorter growing season. Good winter hardiness of forage is required for good longevity.

The Gray Wooded soils in Area 5 are often low in organic matter, have high clay content and can be difficult to manage. Under some conditions, cultivation operations have to be timed according to soil moisture content. Poor soil moisture at seeding and soil crusting can affect establishment. Soil-improving practices such as crop rotations with legumes or grass-legume mixtures can be effective.

Bromegrass and alfalfa are important drought tolerant species and are used for both hay and pasture production. Meadow bromegrass does well as a pasture grass and smooth bromegrass, timothy, alsike clover and red clover are commonly grown for hay. Many species are grown for seed production in Area 5. Forage seed straws are an excellent source of fodder for the beef industry, although there can be problems with some straws such as endophytes in tall fescue. See Table 1 for species adapted to this area.

IRRIGATED AREAS

Southern Alberta: The main irrigated area of Alberta is in the southern part of the province where there are about 1 million acres of irrigated land within the irrigation districts. With the availability of water, soil fertility and management should be high to ensure high forage yields. Multiple cuts of alfalfa are common under intensive production. The use of forages will help maintain soil organic matter and tilth when used in the cropping rotations.

Alfalfa is the most commonly used forage as it is a high value crop when grown for hay or for processing. Timothy is also produced for the export hay market. Irrigated pastures need fast regrowth to take advantage of the irrigation, making species such as meadow bromegrass, orchardgrass and tall fescue ideal pasture grasses in this area. See Table 1 for species adapted to grow under irrigation.

Site Adaptation

In addition to regional adaptation, a forage crop needs to have site adaptation. There is variability in soils and growing conditions within a region, and there is variability in the soils within a field - all affect forage growth. These sites may vary in size from a few acres to large areas. Factors involved include flooding, internal soil moisture drainage, salinity and acidity. Soil texture can affect forage species adaptation as sandy soils can be dry while clay soils are moist.

Some forage crops with specific site adaptations will produce superior yields on soils with specific soil problems. For example, reed canarygrass is very well adapted to wet sites and is very productive on them. Tall wheatgrass is adapted to saline sites with good soil moisture.

Some factors, such as surface drainage, can be determined by observation. Observation can determine what is presently growing on a site or what grows on similar local sites. Soil testing can determine soil pH, salinity, texture and fertility, providing information to help select the forage species to grow or add to a mixture. Problem soils should be sampled separately to identify the problem and severity of the problem to determine the adaptable forage species.

Most forage is tolerant of at least some flooding during spring break-up. Those with low tolerance of excess soil moisture in the root zone are also among the least tolerant of spring flooding. Forages that tolerate longer periods of flooding during the growing season include reed canarygrass, meadow foxtail and creeping foxtail.

Forages rated as having poor acid tolerance in this manual are sensitive to slight acidity, at a soil pH above 6.0. Soil pH affects nitrogen fixation and nutrient availability. Forages with an excellent acid tolerance rating will tolerate quite high acidity (pH below 5.0).

Salinity levels vary from site to site, at different soil depths and from season to season. Forage species tolerance varies depending on variety. Salinity tolerance of crops is improved under good soil moisture conditions. Establishing seedlings are more affected by salinity than established forages. Legume establishment is especially difficult on saline soils. Tall wheatgrass is the most saline tolerant of the cool season forages (see the Fertility section for more information on acidity and salinity).

Intended Use of the Forage

Forages vary in their suitability for hay and pasture. Low growing forages, such as white clover, kura clover and low growing crested wheatgrass varieties, are less suited to mechanical harvesting and more suited for pasture purposes. Legumes tend to be slow drying for hay due to their higher moisture content, with alfalfa being slightly better than other species. Hay curing is more difficult with red and sweet clover.

Legumes require very careful management to persist in pastures, except for white clover and kura clover, which tolerate close and frequent grazing. Most alfalfa varieties are intolerant of frequent grazing although some are being developed with tolerance. Grazing during the critical period can affect the winter hardiness and eventual longevity of legumes, especially alfalfa.

Forage species having high dry matter yields but poorer regrowth are generally more suited as hay species, e.g. smooth bromegrass, timothy, etc. Meadow bromegrass, orchardgrass, tall fescue, Kentucky bluegrass, Italian and perennial ryegrasses, creeping red fescue, alfalfa, kura clover and white clover all have excellent regrowth and make excellent pasture species. Other characteristics of these species such as hardiness, drought tolerance and longevity must be adapted to the soil climatic area in which they will be grown. Characteristics such as tolerance to excess moisture, acidity and salinity will determine their adaptability to a particular site or field within the soil climatic area. Regardless of a forage crop's suitability for pasture or hay, regional and site characteristics will determine if it yields well.

LEGUMES

Legumes

The Legumes

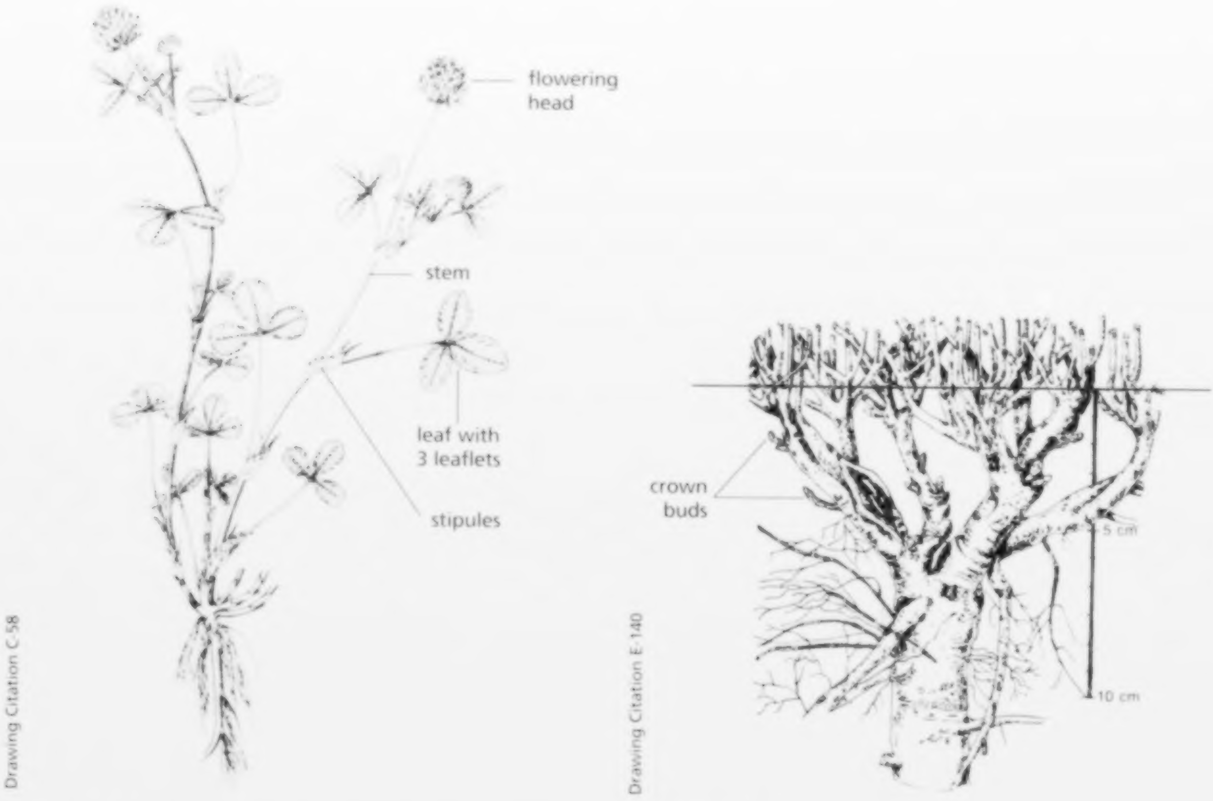
Legumes are high in quality and are used for livestock feed as hay, silage and pasture. As forage crops, legumes are noted for high protein content and high digestibility. They can produce very high yields, mainly as a result of increased soil nitrogen, provided they are properly inoculated with nitrogen-fixing bacteria. Nodules form on the roots and root hairs in a symbiotic relationship with the plant. Legumes regrow well in late summer and fall.

There are nine major species of legumes grown in Alberta, with differences in adaptation between the species as well as between varieties. It is important to choose the species and variety best suited to the soil and climatic areas where they will be grown as well as to consider how they will be utilized. Figure 4 shows representative legume plant features.

Legume stems are branched and generally upright but may be prostate or horizontal, such as with white clover. The growing points of legumes with upright stems are located at the tops of the plants so that consideration must be given to the timing of harvesting, especially grazing.

Most legumes grown for forage have taproots with secondary roots. The taproot in some species may become branched with many lateral roots. The deep taproots of species such as alfalfa enable them to avoid the effects of short-term drought while some species such as white clover have shallow, fibrous roots and are very susceptible to drought.

FIGURE 4
Representative legume plant features



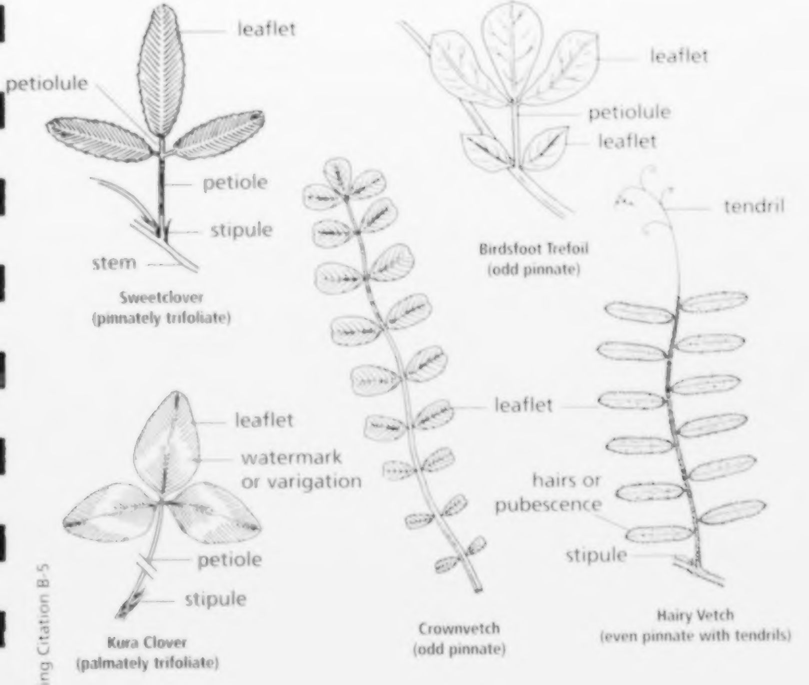
CLOVER PLANT

ALFALFA CROWN

Legume plants increase in size by growth from the original crown or, in some cases, by the formation of new crowns from root portions or rhizomes. However, no legume can increase in stand density to the extent that rhizomatous grasses do. Carbohydrates stored in roots and crowns are used for initial spring growth and regrowth throughout the growing period.

Legumes have opposite leaves with stipules. Alfalfa and clovers typically have three leaflets - two opposite and one at the tip of the petiole (i.e. a trifoliate leaf structure). Other legumes, including sainfoin, cicer milkvetch and sometimes alfalfa leaves, have many leaflets (multifoliate leaf arrangement).

The flowers have five more-or-less united sepals and five petals. The upper petal, called the standard, is larger than the others. The two side petals are called wings, and the two lower ones are joined together to form the keel. Legume flowers are generally colourful, which helps attract pollinators. The fruit is a pod with one or more seeds.


leaflet
petiolule
petiole
stipule
stem
leaflet
petiolule
leaflet
tendril
leaflet
watermark
or varigation
leaflet
hairs or
pubescence
stipule
petiole
stipule

Sweetclover
(pinnately trifoliate)

Birdsfoot Trefoil
(odd pinnate)

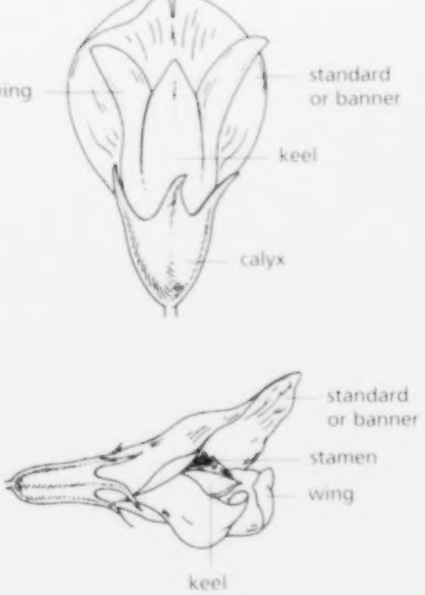
Kura Clover
(palmately trifoliate)

Crownvetch
(odd pinnate)

Hairy Vetch
(even pinnate with tendrils)

Drawing Citation B-5

LEAVES


wing
standard
or banner
keel
calyx
standard
or banner
stamen
wing
keel

Drawing Citation B-6

FLOWER

Alfalfa

INTRODUCTION

Alfalfa (*Medicago sativa* L.) is purple flowered and is thought to have originated in the Middle East. Alfalfa was first grown successfully in Alberta in 1908 when the winter-hardy variegated strain "Grimm" was grown at Suffield. Grimm was a Minnesota strain selected from a German variegated type.

ALFALFA PLANT

Flemish alfalfa originates from French *Medicago sativa* type while Siberian yellow flowered alfalfa (*Medicago sativa* spp. *falcata*) is a sub-species from more northern climates (including Siberia). Variegated alfalfa (*Medicago sativa* spp. *varia*) is a sub-species, developed by crossing *M. sativa* with Siberian alfalfa.

Flemish alfalfa yields and regrows well but generally has only fair hardiness. Siberian alfalfa regrows slowly but has excellent hardiness. Variegated alfalfa has characteristics that are intermediate between them and is commonly used in Alberta. Variegated alfalfa has good winter hardiness, drought tolerance and yield as well as satisfactory regrowth. It includes the dryland type, which is particularly hardy on the Canadian prairies. The winter hardiness of variegated alfalfa varieties is generally associated with the ratio of Flemish and Siberian germplasm present in the cross.

Modern varieties may now represent many genetic sources and may not be identifiable as a distinct sub-species or type by their appearance or other characteristics. For example, many varieties now have the good regrowth ability of Flemish alfalfa combined with good hardiness. Varieties have been developed for various uses and may be described as dryland, hay, grazing, reduced bloat and multifoliate types, etc.

Grazing types have been selected under heavy continuous grazing. Characteristics associated with grazing tolerance include creeping roots, deep set and broad crowns, shoot production extended over time, ability to maintain root carbohydrate levels, etc. While these varieties have been developed for persistence when grazed, adaptation to the area of use, especially winter hardiness, is necessary for persistence in Alberta.

Multifoliate varieties have been developed to be more leafy and of higher quality than trifoliate types. Multifoliate types may have leaves with 5 to 11 leaflets, instead of the usual 3 that trifoliate types have. The proportion of multifoliate leaves varies between varieties, depends on growing conditions and is expressed less in the first cut compared to subsequent cuts. The quality benefit of a multifoliate variety should be supported by quality data. The use of multifoliate types does not mean producers can ignore the benefits of timely and proper harvest management.

Use in Alberta

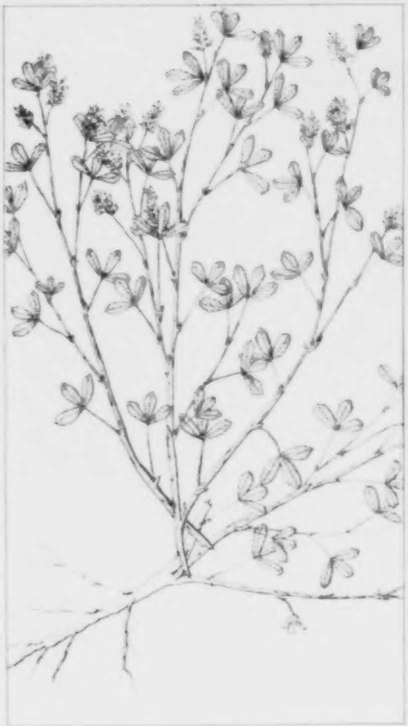
Alfalfa is Alberta's most widely used legume, adaptable to all regions, high yielding and excellent in quality. It is used for hay, silage, pasture and processing. Alfalfa is a good nitrogen fixer (see Table 28 and 29 in the Forage Fertility section). Stands typically produce well for three to five production years. It is palatable to livestock, but may cause bloat in ruminants, which affects its use for pasture.

Alfalfa

DESCRIPTION

Alfalfa shoots develop stems with many branches. Flemish alfalfa has wide leaves and erect stems to about 80 cm (32 in.) in height. Siberian alfalfa has smaller, narrower leaves and finer, less upright stems. Variegated alfalfa has intermediate characteristics.

FIGURE 5
Alfalfa plant and leaflet



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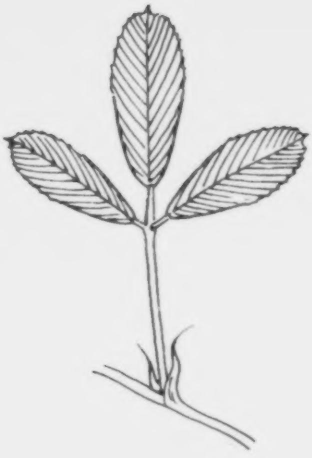

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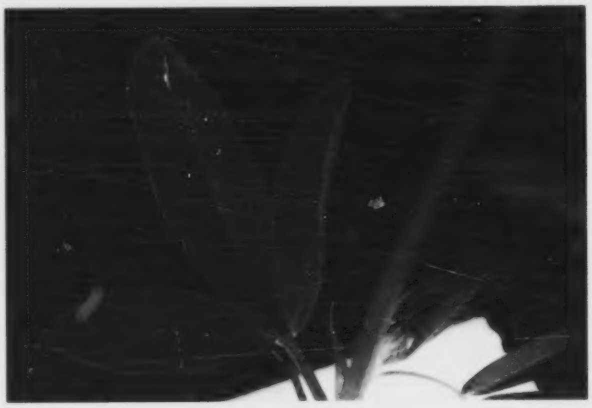
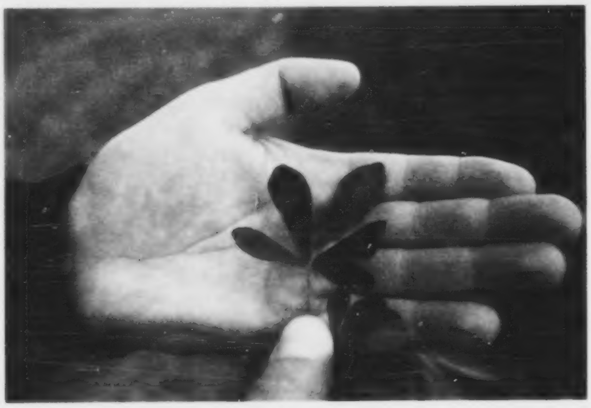
The leaves normally have three leaflets with the center leaflet having a short stock (pinnately trifoliate leaf arrangement). The leaflet margins (edges) are finely toothed from about the midpoint to the tip. Multifoliate types have some leaves with more leaflets.

FIGURE 6
Leaf types

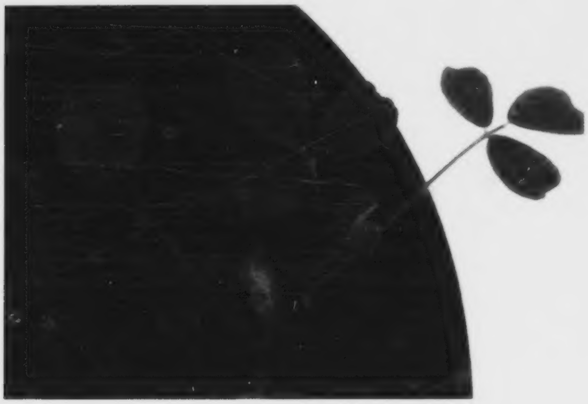


TRIFOLIATE ALFALFA LEAF



MULTIFOLIATE ALFALFA LEAF

Alfalfa has a very deep taproot and a woody crown. Most of the roots are in the upper soil levels, and the plant absorbs most nutrients from there. It can utilize moisture from deep in the soil, making it more drought tolerant than most other legumes and grasses. When compared to grasses, alfalfa has less root mass in the upper soil levels with more at lower levels. Alfalfa requires the *Rhizobium meliloti* nitrogen-fixing inoculant.



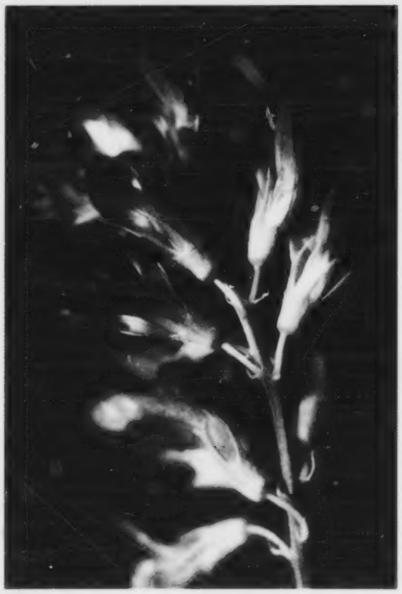
ALFALFA SEEDLING

Flemish alfalfa has a taproot with a few lateral roots and a narrow crown. Siberian alfalfa has widely branching roots and a deep-set crown. Variegated types can be bred to have roots and crowns that are like Flemish, Siberian or intermediate. Creeping rooted varieties have limited spreading ability from rhizomes (underground stems) that grow horizontally from primary roots 10 to 20 cm (4 - 8 in.) below ground level. These shoots may survive as independent plants.

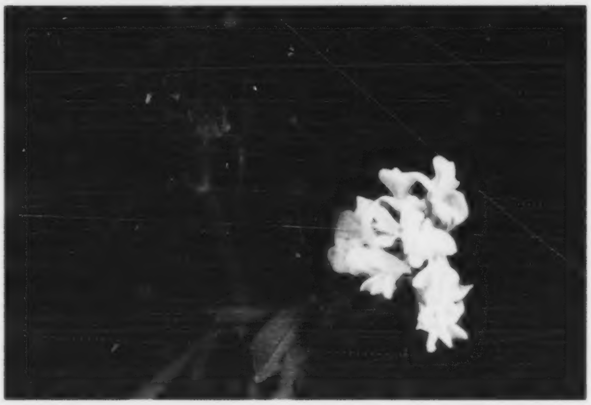
Alfalfa crowns are about 1 to 2 cm (3/8 - 3/4 in.) below the soil surface, which is more than red clover and birdsfoot trefoil but not as deep as sweet clover. Being below the soil surface, the buds on the crown have protection from winter freezing. In the fall, crown buds normally grow to approximately 1 cm (3/8 in.) in length and then remain dormant below the soil surface until spring. In early spring, these buds develop into green shoots.

Flowers emerge from buds at the base of branches, while shoot tips continue to grow (indeterminate growth). Alfalfa flower structures are loose racemes that have up to 20 flowers, each attached to a stalk connected to a common stem. Flowers may be purple (Flemish), yellow (Siberian) or shades of purple, blue, green, cream and yellow (variegated).

FIGURE 7
Alfalfa flower types



FLEMISH ALFALFA FLOWER



SIBERIAN ALFALFA FLOWER

Alfalfa is cross-pollinated. Flemish types have coiled pods with up to 3 or more coils and up to 10 seeds per pod, Siberian types have sickle-shaped pods containing 3 or 4 seeds, and variegated types have between 4 and 10 seeds. Seeds are kidney-shaped, yellow to olive green or brown and 2 to 3 mm long. Hard seed (a hard seed coat impervious to water) commonly occurs.

ALFALFA SEED PODS

GROWTH AND DEVELOPMENT

Alfalfa seedlings are vigorous, emerge and grow quickly and compete well with companion crops, provided measures are taken to minimize competition. Well established seedlings are very winter hardy. Early spring-seeded stands grown under ideal conditions may be hayed by fall but are easily damaged by grazing since crowns are not well developed. Late-seeded stands need at least six weeks of good growing conditions following emergence for good winter survival in Alberta.

Alfalfa sometimes exhibits an effect known as autotoxicity. This effect happens when established alfalfa plants release water-soluble compounds that interfere with the germination and development of alfalfa seedlings (see Rejuvenation section). As a result, plants may die or remain stunted and less productive in subsequent years.

The initial spring growth of established alfalfa is not especially early but occurs quickly with a number of crown buds developing into shoots that form flowering stems. The initial flush of shoots exhibit dominance until they are cut, grazed or mature, at which time, new crown buds begin to grow. This pattern results in a series of growths and good seasonal distribution of production.

Alfalfa initial growth and regrowth are stems with growing points that rise as growth occurs and are removed by cutting or grazing. Regrowth occurs more quickly from buds at the base of the plant or crown than from leaf buds.

Regrowth potential is fair to excellent depending on the variety, and alfalfa is capable of producing multiple cuts where the growing season is long. In Alberta, drier and more northern areas produce one or two cuttings, while areas with more favourable growing conditions produce two or three cuttings.

For pure stands, first-year density of about 160 to 215 plants/m^2 (15 - 20/ft.^{2}) will provide maximum yield. Initial stands with 55 to 110 plants/m^2 (5 - 10/ft.^{2}) may yield slightly less in the establishment year and first production year. If these plants are healthy and have good distribution, they should have adequate density for normal production.

In Alberta, older stands with 30 to 50 or more vigorous plants/m^2 (3 - 5/ft.^{2}) in the moist crop regions or 20 plants/m^2 (2/ft.^{2}) in the drier regions should give satisfactory yields.

Many shoots may grow from one alfalfa crown. The number of shoots or stems produced by a single plant is related to the growing space and vigour of the plant. In any regrowth period, the number of shoots per plant is determined by growing conditions, such as moisture, shade, etc.

Plants die out as a stand gets older, but if the remaining plants are healthy, each crown increases in diameter and will produce more shoots, thus maintaining the number of stems per acre. For example, a healthy mature stand with 45 plants/m^2 (4 plants/ft.^{2}) may have 8 to 10 stems per plant and provide a full yield.

In addition to average plant density and stems per plant, the productivity of a stand is also related to the size of gaps between plants as thinner stands often become patchy.

COMPETITIVENESS AND STAND PERSISTENCE

Alfalfa is a competitive legume that does well in mixtures but is not as aggressive as some grasses. Creeping rooted grasses are especially competitive, with invasive species such as smooth bromegrass reducing the legume component of a stand. Meadow bromegrass and orchardgrass regrow quickly, are competitive with alfalfa throughout the growing season and contribute well to second and third cuts but are not invasive. Bunchgrasses with slow regrowth, such as timothy and crested wheatgrass, do not contribute much yield in second and third cuts. Soils with adequate available phosphorus (P), potassium (K) and sulphur (S) favour alfalfa growth over grass in mixtures whereas soils with high nitrogen levels increase the competitiveness of the grasses.

Stand persistence depends on crown survival. Alfalfa potentially has good persistence and longevity, but productive stand life varies with variety hardiness, growing conditions and management. Well established stands are generally productive for three to five years or more, with very long-lived productive stands being uncommon.

Alfalfa is sensitive to acidity so that yield, vigour and longevity are decreased if it is grown on low pH soils. Crown and root rot diseases often affect its vigour. Soil potassium levels have been shown to be related to alfalfa hardiness although most Alberta soils have adequate potassium.

The age of a stand affects hardiness with new stands being less likely to winterkill than older ones. A one-year-old stand is hardier than a two-year-old stand, etc.

Soil saturated with moisture in late fall is detrimental to winter survival as alfalfa may de-harden. Soils with good internal drainage are less likely to be affected although high rainfall can affect them. Warm weather, with good soil moisture in the fall, promotes growth of crown buds, which delays normal hardening. Cool, dry fall weather favours the increase of root reserve storage and plant hardening.

The minimum soil temperatures that occur over winter affect survival. In 1980, McKenzie and others found that alfalfa may tolerate soil temperatures as low as -8° C one year and -20° C the next, depending on many factors. Low soil temperature in early winter is especially detrimental. The insulating effect of snow decreases the likelihood of winterkill due to freezing.

Ice sheets from winter rainfall or a winter thaw prevent air exchange and smother plants. Air exchange may occur where stubble extends above the ice sheets.

If winter injury has occurred, it is evident in early spring when frost is just out of the ground. Healthy plants have pinkish white crown buds, and the roots and crowns have white interiors. Winterkilled plants have discoloured or brown crown buds, the outer layer of the roots will peel off easily and the roots will be soft and watery with a yellow or brown interior.

Dormancy ratings class varieties according to the amount of regrowth after early fall clipping. Winter hardiness generally increases as fall dormancy ratings decrease, and these ratings have been used to indicate variety hardiness. Alfalfa with a dormancy rating of 1 will be more hardy than alfalfa with a dormancy of 2, etc.

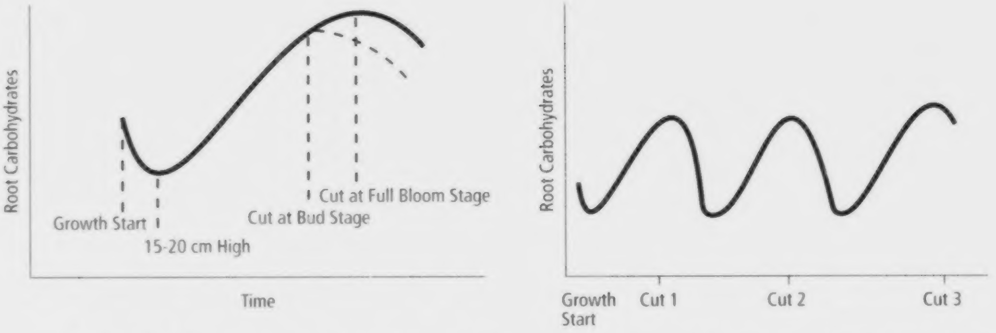
Since some less dormant varieties can tolerate low soil temperatures well, breeding programs have been developed to select for hardiness directly. Siberian and some variegated types, including dryland varieties, are among the hardiest varieties available.

Adequate root carbohydrate reserves in alfalfa are necessary to retain plant vigour and to maintain winter hardiness. Initial spring growth is produced using reserve carbohydrates from the roots as energy. When plant growth reaches 15 to 20 cm (6 - 8 in.) in height, root carbohydrate levels are low, but alfalfa is then able to restore them through plant photosynthesis. They reach high levels by the early bloom stage.

Cutting or grazing does not decrease carbohydrate reserves, but subsequent regrowth does, with the cycle of carbohydrate depletion and replacement being repeated with each successive regrowth (see Figure 8). Minimum levels occur again about two or three weeks after regrowth resumes. Regrowth from frequent cutting or grazing, regardless of the date, reduces root carbohydrate reserves and weakens the plants.

The most critical requirement relating to carbohydrate storage is that alfalfa maintains sufficient levels to be winter hardy. A single cutting in the early flowering stage in drier regions and northern areas or two cuttings in southern Alberta under irrigation do not usually reduce carbohydrate levels enough to reduce winter hardiness. Fairly low clipping height (5 cm (2 in.)) is not detrimental to alfalfa.

FIGURE 8
Alfalfa root carbohydrate levels



Alfalfa Root Carbohydrate Levels from Initial Growth to Cutting

Seasonal Root Carbohydrate Levels when Harvested 3 Times

In northern and central Alberta with two and three-cut harvesting systems, taking the second cutting in early August to mid-September is in the critical harvest period and may cause winter injury and yield reduction the following year. In southern Alberta, the critical period is September and is associated with three-cut systems, with the most common effect being yield reduction the following year. Harvesting in the critical period may not result in stand loss or reduced yield if other factors are favourable.

A general guideline often used in the northern United States and Canada is that the critical period is the four to six weeks before the date of the first killing frost in fall, based on area averages.

The final growth of the year can be harvested without depleting root food reserves provided it is late in the season and regrowth is minimal.

ALFALFA PLANTS

YIELD AND QUALITY

Alfalfa is high yielding with good regrowth ability so that total yield is high. Where adapted in Alberta, it is the legume that generally gives the highest annual yield.

Because alfalfa is a legume, its quality is also high. Quality drops off quickly by the late flowering stage due to leaf loss from the lower part of the canopy. Late in the season, alfalfa may not flower although quality still declines with age.

ADAPTATION

Alfalfa is adapted to a wide range of soils and environments. It is adapted to all soil regions and irrigation areas of Alberta. Varieties with adequate cold tolerance are available for all regions of Alberta.

All soil textures are suitable to alfalfa, provided moisture conditions are satisfactory. Fine clay may be less suitable due to poor internal moisture drainage. Fertile soils, especially those with high phosphorus, potassium and sulphur levels, generally produce the best alfalfa yields.

Alfalfa has excellent drought tolerance. Deep roots make it capable of avoiding the effects of drought for up to a year, and it will survive longer term drought by going dormant. Alfalfa grows on droughty sites, such as sandy or gravelly soils.

Alfalfa has poor tolerance to flooding, waterlogging or poor internal soil drainage during the growing season. It will withstand short-term flooding before growth begins in spring.

Acid tolerance of alfalfa is poor with growth and persistence being reduced on soils with a pH of 6.0 and lower. Yield decreases to less than half of normal below pH 5.5, and stand longevity is reduced. Alfalfa responds positively to liming acid soils to bring the pH up to neutral levels. It has good tolerance to high alkalinity, provided nutrients that are limited by high pH, such as phosphorus, are provided.

Established alfalfa has fair salt tolerance. Growth is affected beginning at about 2 deciSiemen/meter (dS/m), with no growth occurring at about 16 dS/m. It grows satisfactorily in the range of about 4 to 8 dS/m. Alfalfa is deep rooted and can be used to reduce the effects of salinity by intercepting moisture that would bring salt to the soil surface.

Alfalfa is a cool season crop, but it is more adapted to warmer temperatures than most cool season grasses and clovers. Herbage growth occurs well with daytime temperatures from about 10 to 30° C.

LIMITATIONS

Alfalfa longevity is better than most legumes but is still a major limitation. Alfalfa stands begin to thin and become less productive after three to five years. Seeding it on a field where it is well adapted, applying good management and using a suitable rotation period (e.g. three production years) will likely maximize productivity.

Ruminant bloat losses and perceived risk of bloat have also limited alfalfa use, especially for pasture. The use of low bloat varieties and/or various other bloat control measures decreases the risk, making the benefits of alfalfa available.

HAY AND SILAGE

Alfalfa has excellent suitability for hay and is the most commonly used legume for hay in Alberta. It is also commonly used for dehy (dehydrated) and cube production.

Harvesting based on the average stage of maturity of the stand results in a very consistent quality at the time of cutting.

For livestock with lower nutrient requirements, the maximum nutrient harvest per acre may be obtained by harvesting at the early flowering stage (i.e. one open flower per stem). This timing allows for reasonable carbohydrate storage combined with good yield and quality. Leaf loss occurs from the lower part of the canopy by the late flowering stage, and quality drops quickly. Timing of the second cut must be considered relative to the critical harvest season (also see the section on Competitiveness and Stand Persistence).

Harvesting very high quality forage by cutting in the bud stage may be more important than stand longevity in some situations. The use of short rotations (three or four years) with fast regrowth varieties may be appropriate. Having stands of differing ages will reduce the risk of winterkill on the total alfalfa crop.

A possible cutting schedule for high quality hay in central Alberta is harvesting the first cut by the third week of June, the second cutting 35 to 40 days later, by the last week of July, and the third cut at the end of the growing season. In southern Alberta, two high quality cuttings can normally be taken well before September, with a third cutting in October. The second cutting should be taken at least 35 to 40 days after the first cut and before the beginning of the critical period.

A late spring or excessively rainy weather during the harvest season may mean that high quality hay cannot always be obtained. Harvesting during the critical season in two consecutive years is more stressful on alfalfa than a single year.

If a new flush of shoots appears at ground level in a mature stand (e.g. in blossom), then the stand should be cut immediately. The alfalfa should be cut above the level of the new shoots as cutting them will delay regrowth.

If winter injury results in slow spring growth, then the first cutting should be delayed until full flower to enable root carbohydrates to be restored. Crops that are frozen off by a late spring frost should be allowed to flower before cutting. Cold spring weather may also delay cutting dates so that fewer cuttings should be taken. Crops affected by drought should be cut on schedule.

Alfalfa is easy to harvest since it has upright growth and good lodging resistance. Moisture content is lower than many other legumes, so it dries and cures well. Using a conditioner on the mower to crush the stems will speed up the drying process.

Alfalfa can be ensiled satisfactorily. It has high moisture, low water soluble carbohydrate content and a high buffering capacity, which makes it more sensitive to proper procedures when ensiling than cereals are. It is normally wilted in the field to reduce moisture content (see Alberta Agriculture's *Silage Manual*, Agdex 120/52-2, for more information).

PASTURE

Alfalfa has good tolerance to close grazing. Tolerance to frequent grazing is poor (most varieties) to good (grazing tolerant varieties). Alfalfa is sensitive to the depletion of carbohydrates stored in the roots caused by grazing too frequently or grazing during the critical period. Crowns can be damaged by animal treading if the ground is soft.

The growth pattern of alfalfa fits very well with rotational grazing, using rapid, even grazing followed by a long rest period. Alfalfa does not persist very long under continuous grazing.

Alfalfa is well suited to leader-follower grazing. The first grazers may be milking dairy cattle or growing beef cattle, which benefit from high quality pasture. The second grazers may be beef cows or dry milk cows, which have a lower quality requirement and can be forced to graze more stem material.

From a plant survival perspective, stocking should be timed to maintain high root carbohydrate reserves and to avoid grazing in the critical season. If possible, alfalfa should not be grazed in spring until the early blossom stage. Even if the alfalfa is not grazed, the new growth begins to develop at ground level by late flowering, so grazing should be completed before this stage occurs.

In the bud or blossom stage, grazing quite close results in fast regrowth from crown buds. The grazing duration of alfalfa should be a week or less since crown buds begin to develop soon after grazing. The new shoots are easily damaged by trampling or grazing, which will weaken the plant and delay regrowth. Root carbohydrate levels build up to satisfactory levels again when the regrowth reaches the blossom stage.

The rest periods for alfalfa pasture should allow the stand to reach the flowering stage in early August to mid-September in northern and central Alberta and in September in southern Alberta. Later in the season, the alfalfa may not flower, but a rest period of at least 40 days or more is needed. Paddocks that are stressed in one period or season should be given more time to build up root reserves in another. Depending on the location in Alberta, alfalfa can normally be grazed two or three times per season.

Alfalfa can be stockpiled for fall grazing although quality in the field deteriorates excessively over winter if the leaves dry and break off (see Table 15 in the Grasses section).

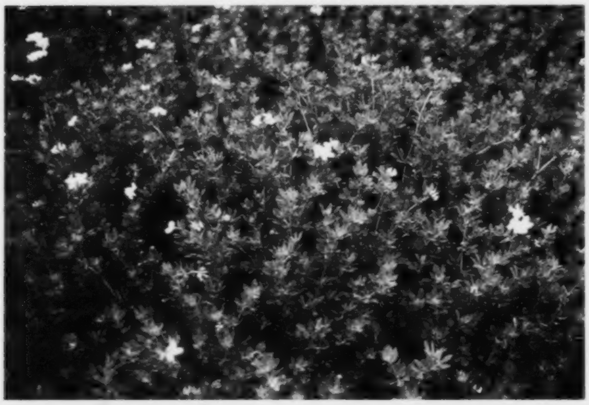
Alfalfa is very palatable and gives high productivity in grazing livestock, although in mixtures, livestock often select leafy grass in preference to alfalfa.

Ruminant bloat is a risk. Alfalfa in the vegetative stage is more likely to cause bloat than alfalfa in the blossom stage. Mixtures using 40 to 50 per cent grasses, especially palatable grasses that regrow rapidly to keep pace with alfalfa, reduce the risk of bloat. Mixing non-bloating legumes that have a high level of condensed tannins, such as sainfoin or birdsfoot trefoil, in a stand of alfalfa will reduce pasture bloat. Alfalfa varieties with a low initial rate of digestion are available to reduce bloat. Other bloat control measures, such as the use of electric fences to control intake, water-soluble products to mix in the drinking water, etc., are available.

Birdsfoot Trefoil

INTRODUCTION

Broadleaf birdsfoot trefoil (*Lotus corniculatus* L.) is native to Europe, North Africa and parts of Asia. It became naturalized in the Atlantic and Pacific states of the United States at an early date. Canadian birdsfoot trefoil varieties have been developed from various sources but mainly from Europe and Russia and have been selected for winter hardiness.



BIRDSFOOT TREFOIL PLANTS

Birdsfoot trefoil is an important legume in central and eastern Canada because of its ability to grow on infertile land, on soils having poor internal drainage and in acid conditions where alfalfa grows poorly. It can be found across Canada where it is not cut or grazed frequently, such as roadsides. This presence is aided by its seed longevity, ability to establish without cultivation and tolerance to a broad range of soil conditions.

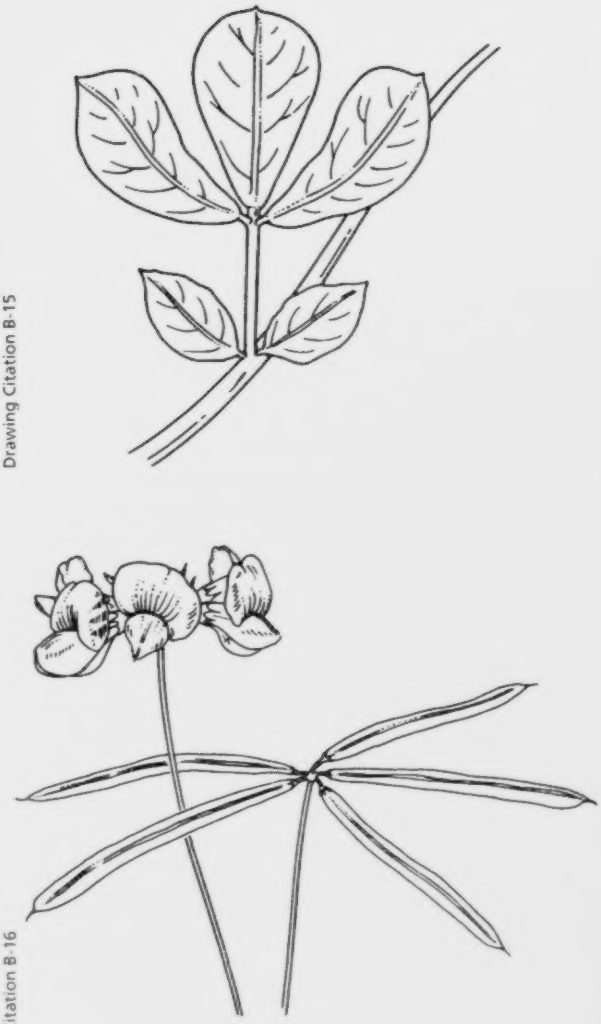
Use in Alberta

Birdsfoot trefoil is used to a limited degree in Alberta, mainly for pasture in higher rainfall areas. Persistence for pasture and hay has been the most limiting aspect for its use in Alberta as most fields have been productive for only one to three years. It is generally significantly lower yielding than alfalfa. Birdsfoot trefoil is very palatable and does not cause bloat in grazing ruminants because of its tannin content.

DESCRIPTION

Many branched stems grow from the crown of the plant. Stems are finer than those of alfalfa and are up to 75 cm (30 in.) or more in length, although stand height is less. The stem base generally lies on the ground with the main stem growing upright (decumbent), but it may be erect or prostrate. In prostrate plants, the stems may develop from crown buds below ground level and grow for a short distance below ground before emerging.

FIGURE 9
Birdsfoot trefoil leaf, flower and seed pod

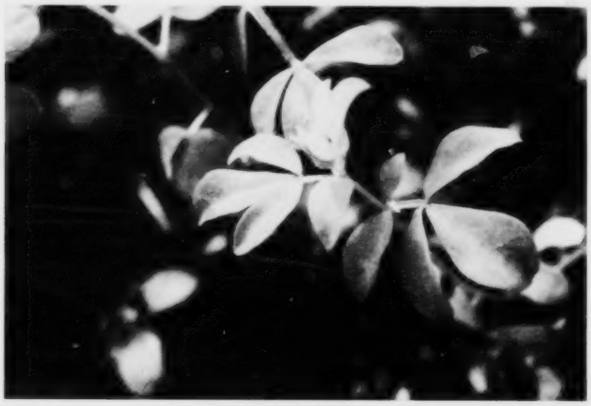


Drawing Citation B-15

Drawing Citation B-16

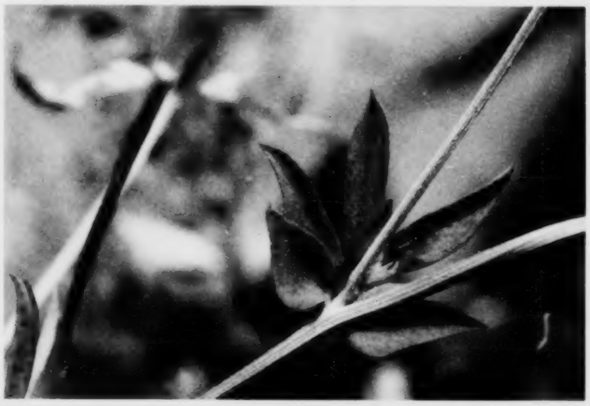
Birdsfoot Trefoil

Birdsfoot trefoil has compound leaves made up of five leaflets. There are two pairs of leaflets on the leaf stock plus a leaflet at the tip (odd pinnate leaf arrangement). The first two leaflets are at the base, and three are grouped at the end of the leaf stock (petiole).



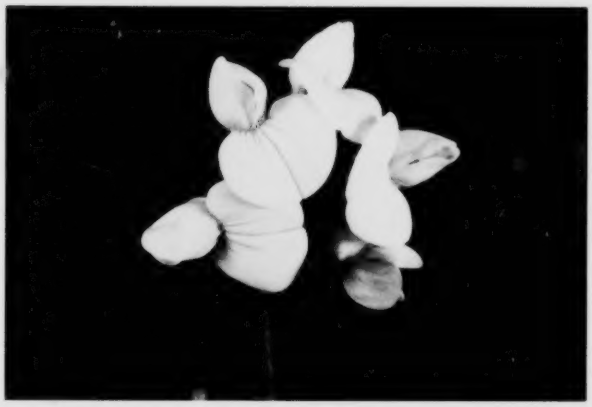
BIRDSFOOT TREFOIL SEEDLING

Birdsfoot trefoil has a fairly deep taproot and a wide, woody crown. Crowns and roots are deeper than those of red clover but not as deep as alfalfa. Roots have many side branches in the upper soil levels. Older stems that contact the soil may put down roots, and shoots can develop from roots. Birdsfoot trefoil requires its own specific *Rhizobium loti* inoculant to fix nitrogen.



BIRDSFOOT TREFOIL LEAF

Flower formation, occurring over an extended period, begins on lower branches and proceeds up the stem. Birdsfoot trefoil flower clusters are umbels, i.e. they are on stalks from a common point. There are two to eight flowers on each cluster. Flowers are bright yellow and may have faint orange or red stripes.



BIRDSFOOT TREFOIL FLOWER

Birdsfoot trefoil is cross-pollinated, and each flower can produce a cylinder-shaped pod up to about 4 cm (1 1/2 in.) long with 10 to 20 or more small seeds. The pods are at right angles to long stalks, making them look like the toes of a bird's foot, which is how the name was derived. When ripe, the pods burst open, dispersing the olive green to dark brown seeds. Hard seed is usual, and it can remain in soil without germinating longer than most legumes, although it is easily scarified (nicked or scratched), which facilitates germination.

BIRDSFOOT TREFOIL SEED PODS

GROWTH AND DEVELOPMENT

Birdsfoot trefoil seeds are very small and require a shallow seeding depth (3 - 6 mm). Seedlings have slow growth initially, poor shade tolerance and are not competitive, enabling companion crops, broadleaf weeds or grasses to reduce their ability to establish. Despite lack of vigour, birdsfoot trefoil seedlings establish well under favourable conditions and will establish in existing stands and non-farm areas. Birdsfoot trefoil is usually established by the year following seeding, but it benefits from light use initially.

In established plants, the initial flush of spring growth is from crown buds. The shoot tips continue to grow while the plants are flowering (indeterminate growth). Regrowth is from existing growing points on the shoots, including buds on the stubble remaining after cutting or grazing. The rate of regrowth is good, making for a good distribution of growth. Buds for the next year's growth are initiated in the fall.

Carbohydrates in the roots are used for initial spring growth from the crowns, and vigour is closely related to the amount stored. Carbohydrate reserves are maintained at a minimal level during summer, with plants depending mainly on photosynthesis to provide energy for regrowth.

Birdsfoot trefoil is able to regrow well after cutting provided enough green leaf material is left, but it is weakened by close cutting or grazing. Rest or light use in late summer and fall enable root reserves to build up for winter.

COMPETITIVENESS AND STAND PERSISTENCE

Birdsfoot trefoil is lower growing than most forages, is intolerant of shade and lacks competitiveness. Non-aggressive grasses, such as timothy, or lower growing grasses and legumes are the most suitable for mixtures. Birdsfoot trefoil may be more competitive in mixtures when growing conditions, such as fertility or acidity, are less favourable for companion plants. Growing birdsfoot trefoil in pure stands is risky because of its poor persistence.

Plant persistence depends on crown survival. Birdsfoot trefoil has had poor hardiness and longevity for pasture and hay although good snow cover improves winter survival. Stand persistence is very dependant on re-seeding, which may be best accomplished by building up a seed bank in the soil by letting the forage set seed.

Birdsfoot Trefoil

YIELD AND QUALITY

Birdsfoot trefoil produces annual yields that are considerably less than alfalfa. Quality is excellent and, on average, slightly superior to alfalfa. Due to good leaf retention and indeterminate growth, birdsfoot trefoil retains quality into later maturity stages somewhat better than alfalfa.

ADAPTATION

Birdsfoot trefoil is adapted to the higher rainfall regions of Alberta, including Gray Wooded and Black soil zones. It is adapted to a broad range of soil types from clay to sandy loams, and it will grow on organic soil. It is tolerant of low fertility soils although it needs at least moderate amounts of nutrients.

Fairly deep taproots provide birdsfoot trefoil with fair drought tolerance, less than alfalfa. It has good tolerance to poorly drained soil and will tolerate short-term flooding. It will not tolerate areas where standing water persists for long periods in summer.

Birdsfoot trefoil has good acid tolerance. It will tolerate pH down to about 5.0 but does best above pH 6.0 with 6.5 being ideal. Birdsfoot trefoil has good salinity tolerance. It has fair tolerance to alkalinity, similar to alsike clover.

LIMITATIONS

Stand persistence is the major limitation to birdsfoot trefoil use in Alberta, and, as a result, it has been used very little. This situation is related to a number of factors including poor winter hardiness, lack of competitive ability and root reserve depletion.

Using it lightly in the first utilization year will help the stand to establish well. It needs to build up a seed bank in the soil as stand persistence depends partly on natural re-establishment. Birdsfoot trefoil stands persist well in non-crop areas, such as roadsides, indicating it does have the ability to persist well.

HAY AND SILAGE

Birdsfoot trefoil yield increases until about mid-bloom. A reasonable trade-off between yield and quality is attained by harvesting in early bloom. Late summer or early fall hay harvest weakens the plants.

Lodging is common, making hay harvesting more difficult. A stubble height of 10 cm (4 in.) provides enough buds and leaves for good regrowth. Leaf shattering is a problem with birdsfoot trefoil. It is also harder to cure for hay than alfalfa.

PASTURE

Birdsfoot trefoil is best suited for pasture use. It has good tolerance to frequent grazing provided it is not grazed close. It has only fair tolerance to close grazing and does not provide high treading tolerance since it is a crown-forming legume.

Birdsfoot trefoil persists best with light rotational grazing and stocking intervals of a week or less to avoid grazing new buds. With continuous grazing, it is difficult to control the closeness of grazing, and birdsfoot trefoil may be selectively grazed in mixed stands.

Initial spring grazing of birdsfoot trefoil should, as a minimum, not be initiated before a full canopy (full ground cover) develops. At least a 10 cm (4 in.) height of leafy residue should be left after grazing to provide growing points and photosynthesis for regrowth. Leaving some flowers to set seed is beneficial. The regrowth period needs to be sufficient, at least four to six weeks under good growing conditions, for good recovery before grazing again.

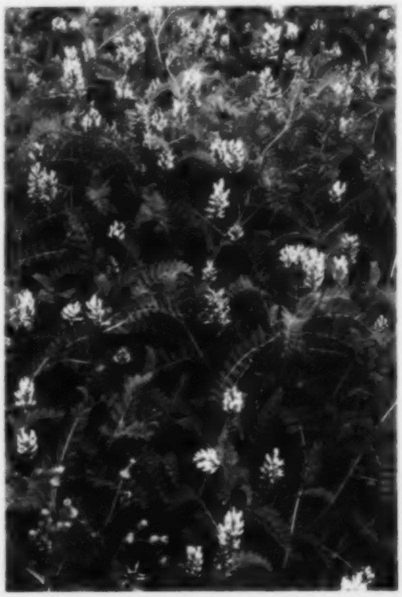
In late summer and fall, it needs to be rested or used very lightly to allow root carbohydrates to accumulate.

Birdsfoot trefoil has excellent palatability for grazing livestock. It is not bloat-causing due to tannins and is digested more slowly when compared to alfalfa.

Cicer Milkvetch

INTRODUCTION

Cicer milkvetch (*Astragalus cicer* L) is native to Europe and Russia. It was introduced to the United States from Sweden in 1926 and to Canada from Russia in 1931.



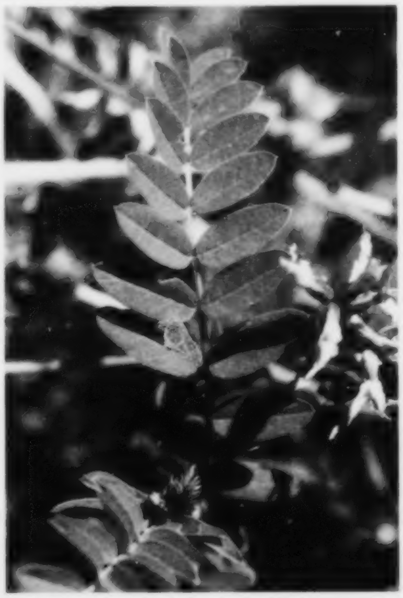
CICER MILKVETCH PLANTS

Use in Alberta

Cicer milkvetch is used to a limited degree in Alberta, mainly for pasture production. It is difficult and slow to establish, and it has moderate productivity. Its main advantages are good longevity and that it is non-bloat-causing to ruminant livestock. Cicer milkvetch can be grown on Black, Dark Brown, Gray Wooded and irrigated soil areas.

DESCRIPTION

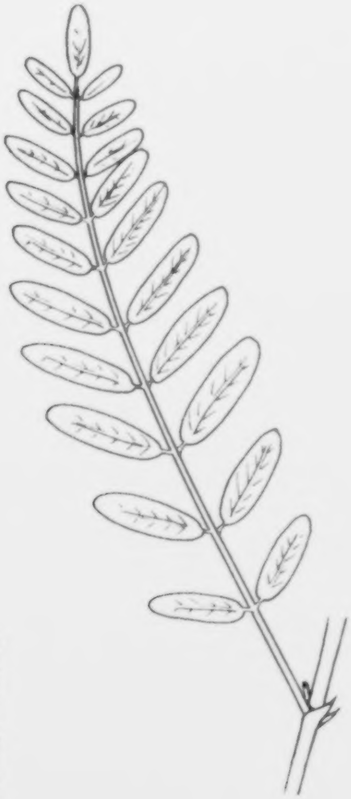
Initial spring growth of cicer milkvetch is upright, but later, the stems may trail on the ground, with the growing end being upright. The coarse, hollow, succulent stems can reach 120 cm (4 ft.) in length under good growing conditions while stand height may reach about half its length. Leaves are compound with 13 to 27 somewhat hairy leaflets in pairs on opposite sides of the leaf stock (petiole) with one leaflet at the tip (odd pinnate leaf arrangement). Leaves are up to about 15 cm (6 in.) long with green or whitish stipules.



CICER MILKVETCH LEAF

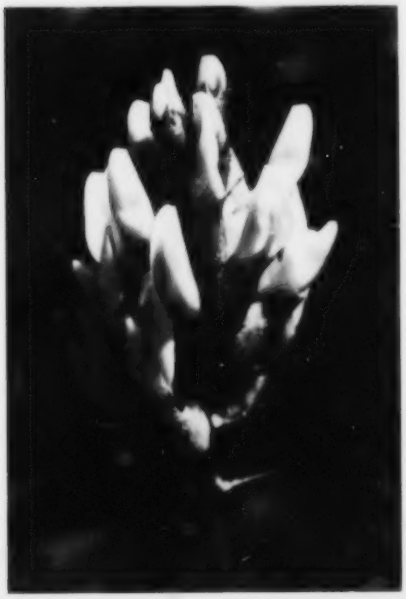
Cicer Milkvetch

FIGURE 10
Cicer milkvetch leaf



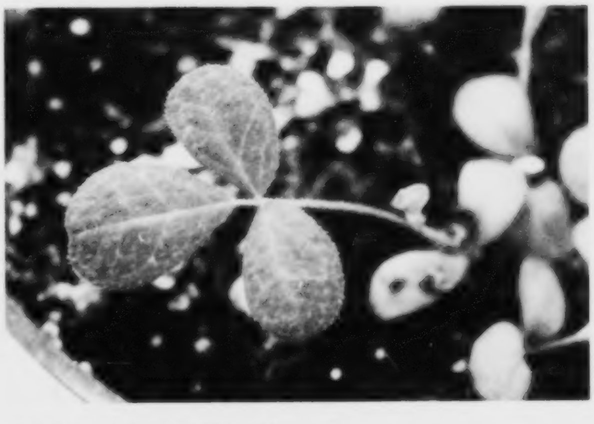
Plants develop a deep, branched taproot with broad crowns. Rhizomes enable it to expand and increase persistence.

The heads (racemes) have up to about 40 flowers that are attached to stalks connecting them to a common stem. The heads develop from buds between the leaves and the stems, enabling the stem to keep growing and new flower heads to emerge over an extended period (indeterminate growth). Flowers are pale yellow to white.

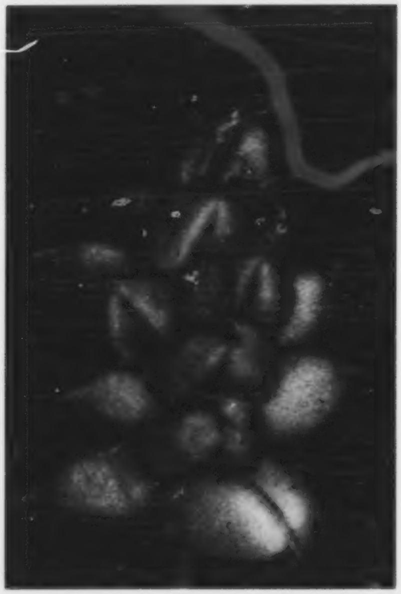


CICER MILKVETCH FLOWER

Cicer milkvetch is cross-pollinated; seed pods are up to 15 mm long, appear inflated, green to slightly red and become black and tough at maturity. Pods have up to 12 bright yellow to pale green seeds that are about twice the size of alfalfa seeds. The pods are not easily shattered, and the seed coat is hard and impervious to moisture. Seed scarification is normally required to ensure adequate germination.



CICER MILKVETCH SEEDLING



CICER MILKVETCH SEED HEAD

GROWTH AND DEVELOPMENT

Cicer milkvetch seedlings are slow to emerge, slow to grow, are not competitive and establish best without a nurse crop. Newer varieties have improved establishment. Milkvetch (*Astragalus spp.*) inoculant is required for nitrogen fixation. Two or more years may be required to establish cicer milkvetch.

Growth of established stands begins late in spring, and it has only fair regrowth ability after grazing or cutting. Growth of unclipped stands continues, at least to some extent, until the end of the growing season.

Carbohydrate reserves in the roots and rhizomes are maintained at a minimum level during the growing season. When cut or grazed, the plants depend mainly on existing leaves to photosynthesize energy for regrowth. It regrows well after cutting or grazing, provided enough leaf material is left, but it regrows slowly if it is closely clipped.

COMPETITIVENESS AND STAND PERSISTENCE

Established cicer milkvetch is fairly competitive, grows well in grass mixtures and has excellent winter hardiness. Plant crowns and rhizomes enable good persistence and longevity, especially under favourable soil moisture conditions. Rhizomes enable it to spread.

YIELD AND QUALITY

Cicer milkvetch yields considerably less forage than alfalfa. Digestibility and protein levels are generally slightly higher than alfalfa and red clover, but less than alsike and white clover. Due to good leaf retention, quality is maintained at late maturity stages. Plants remain green until late fall so that late season quality is good, relative to the stage of maturity. Cicer milkvetch does not accumulate high levels of selenium like some native milkvetch species.

ADAPTATION

Cicer milkvetch is adapted to the Black, Dark Brown, Gray Wooded and irrigated crop areas of Alberta. It performs well on a wide range of soil textures provided internal soil moisture drainage is good. Rhizomes spread most on coarse soils.

This legume has good drought tolerance, but is less productive during a drought than alfalfa. It has only fair tolerance to excess soil moisture and will only tolerate short-term flooding during the growing season.

Cicer milkvetch has fair tolerance to soil acidity and salinity. It has good tolerance to alkalinity. Rhizomes provide resistance to damage from pocket gophers.

LIMITATIONS

Slow emergence and seedling growth, which can result in poor stands or failure to establish, are the main limitations of cicer milkvetch. Two years may be required for establishment unless conditions are very favourable.

HAY AND SILAGE

Cutting cicer milkvetch at about the 25 per cent flowering stage gives a reasonable compromise between yield and quality. If available, a second cutting can be taken at the end of the growing season. Leaf retention during haying is better than that of alfalfa. It is slow to dry as hay.

PASTURE

Cicer milkvetch is most often used as pasture. It has only fair tolerance to close grazing as it requires leaf photosynthesis for best regrowth ability. It has good tolerance to frequent grazing, provided it is not grazed too close, which results in slow regrowth. Rhizomes provide good tolerance to animal treading.

Cicer milkvetch does best with light rotational grazing although light continuous grazing is satisfactory. At least a 10 cm (4 in.) height of leafy residual should be left after grazing to enable photosynthesis for regrowth. Growth can be somewhat prostrate, which may increase the amount of residue remaining. The rest period needs to be long enough for good recovery before grazing it again.

Cicer milkvetch remains leafy and can be stockpiled for grazing after the end of the growing season. The quality of regrowth is adequate for good gains in dry beef cows in fall and may be adequate for maintaining cow weight the following spring after overwintering in the field.

Cicer milkvetch has good palatability, and animal gains are normally good. It is non-bloat-causing.

Alsike Clover

INTRODUCTION

Alsike clover (*Trifolium hybridum* L.) is native to northern Europe. It was cultivated in Sweden as early as 1750. It was introduced into northern Alberta as a seed crop in about 1932. Alsike clover is not a hybrid as was once thought.

Colin Stone

ALSIKE CLOVER PLANT

Varieties of alsike clover grown in Canada are either of a diploid (2n = 16) or tetraploid (2n = 32) type. The most common type grown in Alberta is diploid. Tetraploids, with double the number of chromosomes, are taller, have larger leaves and flowers and are later flowering than the diploids.

Use in Alberta

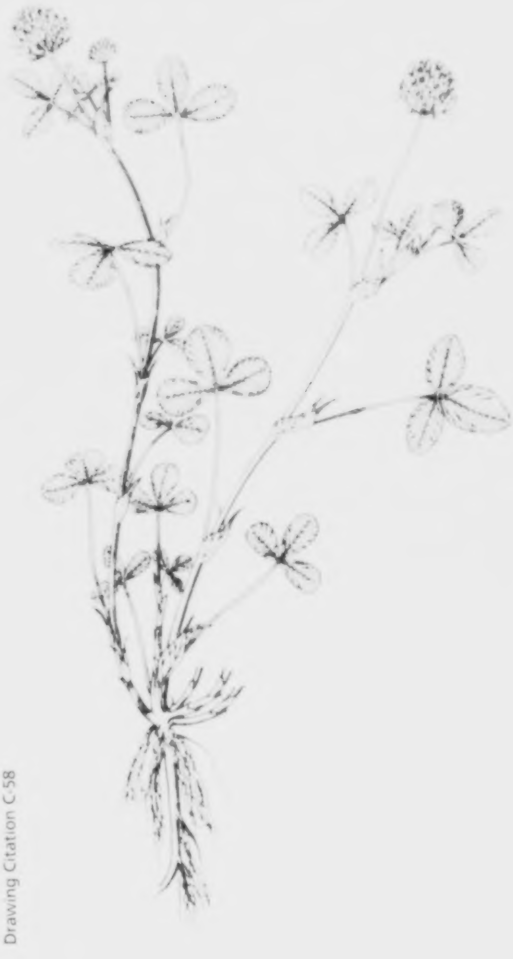
Alsike clover is adapted to high precipitation areas of the Gray Wooded and Black soil regions. It is commonly used in short rotations for hay, silage and pasture, often in mixtures with timothy, and its main limitation is lack of longevity. Alsike clover is often used in areas where higher yielding legumes are not adapted, such as moist acidic soils. Cultural practices are similar to red clover. Alsike clover is a good nitrogen fixer, comparable with other well adapted perennial legumes. It is satisfactory for use as green manure (plow-down).

Alsike clover is very palatable and nutritious, although it is bloat-causing, and photosensitization is sometimes associated with it, especially with horses.

DESCRIPTION

Stems grow to 60 cm (24 in.) or more, are erect to semi-erect, more slender than those of red clover and tend to be weak. Stems do not terminate at a flowering head, but instead, they continue to grow (indeterminate growth) and may become quite long. The stems and leaves have no hair.

FIGURE 11
Alsike clover



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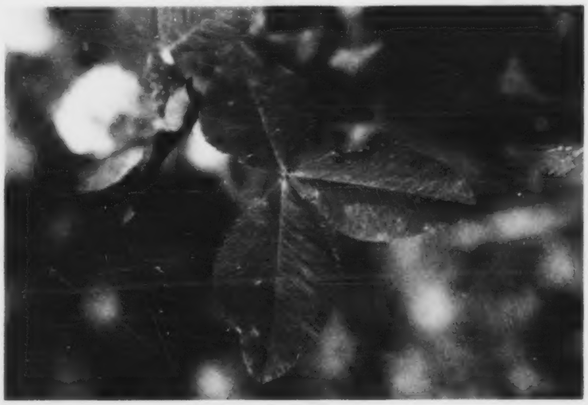
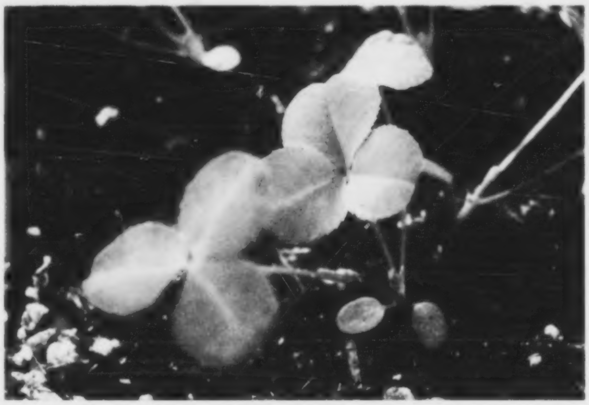
Alsike Clover

The leaves have three leaflets attached from a single point (palmately trifoliate). The leaflets have finely toothed margins, but no watermark (V marking), which makes it easy to differentiate from the other clovers. Stipules are large, membranous and conspicuously nerved.



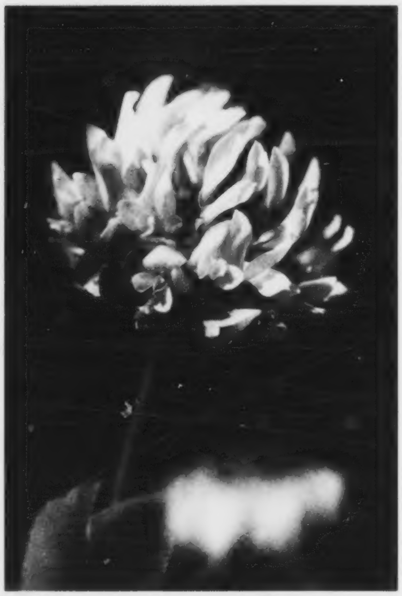
ALSIKE CLOVER LEAF

The taproots are branched but shallow, have well developed crowns and do not creep. Alsike clover uses the same *Rhizobium trifolii* inoculant as red and white clover to fix atmospheric nitrogen.



ALSIKE CLOVER SEEDLING

Alsike clover blooms profusely with flower heads (compact racemes) forming at the leaf axils and continues to bloom for an extended period. Flower heads are globe-shaped, smaller than those of red clover, long stalked and have up to about 50 pink to white flowers. Alsike clover is cross pollinated and sets seed over a wide range of conditions, producing oblong pods, about 3 to 4 mm long, with 2 to 4 small, greenish to yellow to black seeds per pod. Like red and white clover, alsike may have a high hard seed count.



ALSIKE CLOVER FLOWER

GROWTH AND DEVELOPMENT

Alsike clover is easy to establish. The seed is small, so it must be shallow seeded (about 5 - 10 mm depth), and establishment begins slowly. The seedlings have only fair shade tolerance but are tolerant of companion crops if measures are taken to minimize competition. Alsike clover can be established where there is minimal land preparation, and it produces a full yield in the year after spring seeding. If seed is allowed to set, voluntary establishment can occur.

Alsike clover is a short-lived, fast growing perennial legume. The shoots develop from crown buds in spring, producing one main flush of growth. Growth is indeterminate, enabling the plants to continue to grow during blossoming. Growing points of stems rise as they grow. Regrowth ability is good early in the season.

Initial spring growth depends on energy from root storage. Cutting or grazing too frequently diminishes root carbohydrates and weakens the plants. Light use in fall enables root carbohydrate reserves to build up for winter.

Alsike Clover

COMPETITIVENESS AND STAND PERSISTENCE

This clover is vigorous and grows well with less competitive grasses, such as timothy. Stands depend on crown survival and natural seed set for persistence. Internal breakdown of crowns and roots occurs due to nutrients being transferred to growth areas. Stands are short-lived, usually persisting for two to three years. It has good hardiness although winterkill sometimes occurs.

YIELD AND QUALITY

Alsike clover produces modest first-cut yields followed by vegetative regrowth. Where both species are adapted, alsike clover generally yields somewhat less than red clover. Quality is very good, similar to that of red clover at full bloom. Since alsike clover has indeterminate growth, its quality holds up better than red clover at more mature stages.

Toxicity to horses, and occasionally to cattle or sheep, has been associated with alsike clover. This toxicity is expressed as a reaction to sunlight and liver problems. It usually occurs on pasture but may occur with feeding alsike hay.

ADAPTATION

Alsike clover is adapted to the higher rainfall areas of the Gray Wooded and Black Soil regions. It is well adapted to cool, moist climates, including high altitude and northern areas. It does not do well in areas with hot summers. It does well on various soil types if there is sufficient moisture and does especially well on moist clay soils. It is well suited to peat (organic) and inorganic soils.

Alsike clover has poor tolerance to drought. It has good tolerance to excess soil moisture and is often grown on soils with poor internal drainage. It can withstand several days of flooding during the growing season.

This clover has good acid tolerance, similar to red clover, and grows on soils with a pH as low as 5.0. Alsike clover has good alkalinity tolerance, although it has poor tolerance to salinity.

LIMITATIONS

The main limitations of alsike clover are modest yield and short life span. Stands typically remain productive for two to three years.

HAY AND SILAGE

Alsike clover is normally harvested at early to full bloom, with only one cutting each season. Regrowth is low growing and best suited to grazing.

Alsike clover is normally grown in mixtures with grasses such as timothy to reduce lodging problems for easier cutting and for faster drying. It is high in moisture content, making it slow to dry in the field, with wilting needed for ensiling. It is used more for hay in Alberta than red clover, partly due to slightly lower yield, which makes it easier to dry in windrows.

PASTURE

It is somewhat difficult to control the proportion of alsike clover in a mixture since it tends to dominate the stand for the first one or two years before it begins to go out of the stand.

Alsike clover has fair tolerance to close grazing and good tolerance to frequent grazing. Continuous, close grazing is very detrimental to it. It has poor tolerance to animal treading.

Alsike clover is more persistent with rotational grazing than with continuous grazing. Paddocks should be grazed with a short grazing duration (a week or less). It has good regrowth ability in pasture.

Initial spring grazing should not begin before a full canopy (full ground cover) of leaves develops. At least 10 cm (4 in.) of leafy residual material should be left after grazing. A regrowth period of four weeks or more is needed before grazing again. It should be rested or grazed lightly during the last four to six weeks of the growing season to enable carbohydrate reserves to accumulate for winter survival.

Alsike clover is very palatable and may be grazed selectively. Intake is high and quality is excellent, giving good animal performance. It is bloat-causing, similar to red clover and alfalfa, especially in the vegetative stages. Photosensitization, especially with horses, sometimes occurs (see Yield and Quality).

Kura Clover

INTRODUCTION

Kura clover (*Trifolium ambiguum* Bieb.) is also called Caucasian clover. The names relate to its region of origin, which includes the Kura River and the Caucasian Mountains in south-eastern Europe. Its area of natural adaptation includes valleys and sub-alpine meadows. It is adapted to parts of the United States, including the northern Midwest, where there is sufficient moisture.

KURA CLOVER PLANTS

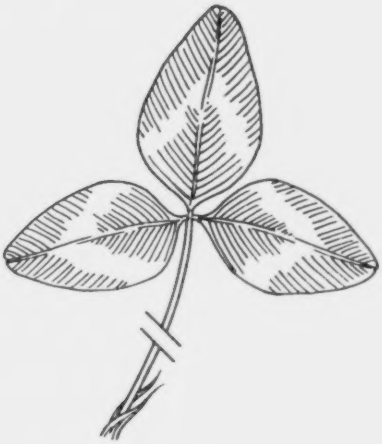
Kura clover is a common clover (*Trifolium* sps) along with red, white and alsike clover. It is more closely related to white and alsike clover than to red clover. Present varieties in use in Canada are hexaploids.

Use in Alberta
Kura clover is a new crop to Alberta, so its use and areas of adaptation are not well defined. It appears to be adapted to Black and Gray Wooded soils. It should have good potential as a pasture crop due to its good persistence, fairly low growth habit and grazing tolerance. It is very palatable but is bloat-causing.

DESCRIPTION

Most kura clover stems are near ground level at the base with the outer portion extending upwards (prostrate to decumbent). Stems are up to about 50 cm (20 in.) long, but stand height is less.

FIGURE 12
Kura clover leaf and plant



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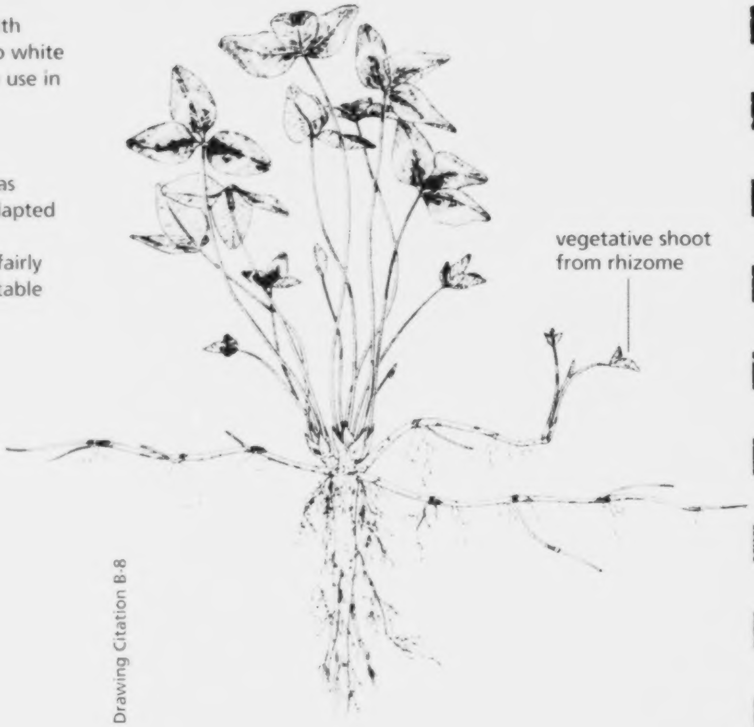

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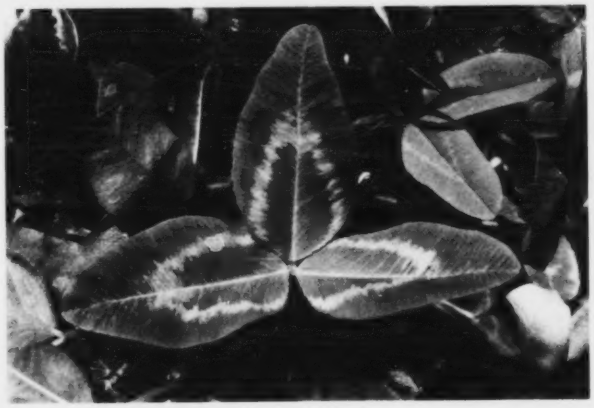
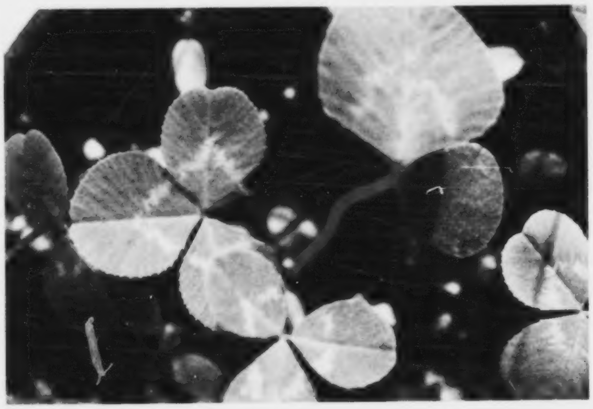
Kura Clover

Kura clover has a high leaf-to-stem ratio. The leaves have three leaflets attached at the same point (palmately trifoliate). Leaflets are oblong, up to about 8 cm (3 in.) long and 5 cm (2 in.) wide with narrow but rounded tips. In present varieties, most leaflets have a whitish watermark (V marking) on the upper surface. Leaves and stems are hairless or nearly so.



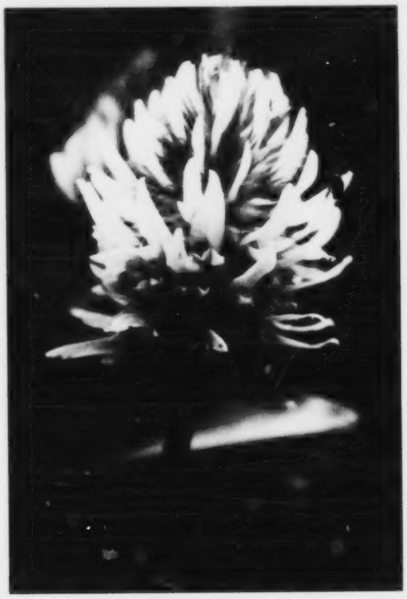
KURA CLOVER LEAF

Kura clover develops a deep-set crown that is as much as 5 cm (2 in.) below the soil surface and a deep, branched taproot. It has underground horizontal stems (rhizomes) that grow from the crowns, spread, branch and develop additional, attached plants. A vigorous, mature stand has an abundance of roots and rhizomes. Kura clover requires a different *Rhizobia* inoculant (*Rhizobium* spp.) than alsike, red, white or sweet clover.



KURA CLOVER SEEDLING

Flowers are in oblong or globe-shaped heads (compact racemes) and are white, becoming pinkish with age. Heads are large, up to about 2 cm (3/4 in.) wide and 3 cm (1 1/4 in.) or more in length. Kura clover is cross-pollinated. Pods have one or two dull yellow to reddish brown seeds. Hard seed content may be high, and scarification of the seed may be required.



KURA CLOVER FLOWER

GROWTH AND DEVELOPMENT

Kura clover seedlings have poor vigour and lack competitive ability. Competition from companion crops and weeds is very detrimental and can result in establishment failure. Stands are slow to establish, due in part to the development of a large root system, and may require up to two years to be fully established.

Established kura clover spreads and thickens by developing additional plants from rhizomes. A low density stand can gradually become dense.

The first spring flush of growth has some stems, which are determinate, while regrowth is composed of leaves. Most of the growing points are lower and less exposed to grazing than those of more upright legumes, such as red and alsike clover. It is capable of regrowing from above-ground growing points, crowns and rhizomes. Excellent regrowth ability gives kura clover a good distribution of growth throughout the summer.

The large mass of roots, crowns and rhizomes provides kura clover with a large carbohydrate storage capacity, which is not depleted quickly. This feature gives it good regrowth ability and persistence.

COMPETITIVENESS AND STAND PERSISTENCE

Established stands of kura clover are very competitive and maintain a high plant density. It does well in mixtures with grass, although it spreads and thickens more slowly in a mixture. Deep-set crowns and rhizomes provide good winter hardiness and persistence, enabling it to be a long-lived perennial legume. It can survive more severe winters than less hardy grasses, such as orchardgrass.

YIELD AND QUALITY

Kura clover gives very high pasture production as it has high yields and persistence when it is clipped frequently, a combination not found in other legumes used in Alberta.

Kura clover has high protein content and digestibility. The initial spring flush of growth has a high leaf-to-stem ratio, and regrowth is almost all leafy material. For comparable stages of maturity with other forages, kura clover generally has a higher quality than other perennial legumes used in Alberta, except white clover.

ADAPTATION

Kura clover is expected to do well in Black and Gray Wooded soil regions. It will grow on most soil textures, including clay, silt and sand, provided moisture conditions are favourable.

Kura clover is expected to have fair to good drought tolerance due to its deep roots. Rhizomes provide an ability to survive periods of dormancy such as those caused by severe drought. It has fair tolerance to poor soil drainage (high water table), but not to the same degree as alsike clover, and will tolerate some flooding during the growing season.

Kura clover has fair tolerance of acidic soils but does best on neutral to slightly acidic soils (from about pH 6.0 - 7.0). It has poor tolerance to salinity.

LIMITATIONS

Kura clover is noted for poor seedling vigour and slow establishment, and it may require up to two years for it to establish fully.

Varieties presently used have poor seed production, which may limit seed availability.

HAY AND SILAGE

Kura clover is poorly suited to hay production due to its low growth habit. The first growth is the most suitable for machine harvesting as it has some stem development and is taller. Quality is generally suitable in the early to full flowering stages. Like most clovers, the moisture content is high, which makes curing more difficult than for alfalfa, and care needs to be taken to prevent leaf loss. Regrowth is mainly leaf material and is most useable for grazing.

Kura clover can be ensiled satisfactorily. Its high moisture content normally requires that it be wilted.

PASTURE

Kura clover is very productive and persistent, making it very well suited for pasture production. It is fairly low growing and has excellent tolerance to close and frequent grazing. Established stands have a large mass of roots, rhizomes and crowns, enabling it to store energy for excellent regrowth following grazing. It provides good tolerance to livestock treading.

Rotational grazing is advantageous because the highest yield is obtained if it is not grazed too frequently. It is more tolerant of close, continuous grazing than other common clovers used in Alberta, except for white clover.

Initial spring grazing can begin when a full canopy (full ground cover) develops. It can be grazed down to about a 10 cm (4 in.) height of leafy residue. Under good growing conditions, it regrows quickly and can be grazed in four to six weeks. It should be grazed lightly during the last four to six weeks of the growing season in the fall to allow root reserves to be replenished.

Kura clover has excellent palatability. It can cause bloat in ruminants, and its high palatability and quality increases the likelihood of bloat occurring, especially when grazing in the vegetative stage.

Red Clover

INTRODUCTION

Red clover (*Trifolium pratense* L.) is native to Europe and Turkey. It was introduced into Canada over 200 years ago. It is the most commonly grown clover in Canada, although in Alberta, alsike clover may be used more often. Altaswede red clover, a single cut variety, was selected from Swedish seed stock by the University of Alberta in about 1919.

RED CLOVER PLANTS

Single cut types are, by far, the most commonly grown red clover forage in Alberta. They are also known as mammoth or late-flowering red clover, and when grown for hay, they provide one main cut per year plus some regrowth. Double cut varieties are also known as early flowering or medium red clover and can have multiple cuts. They are not as hardy or persistent as single cut types.

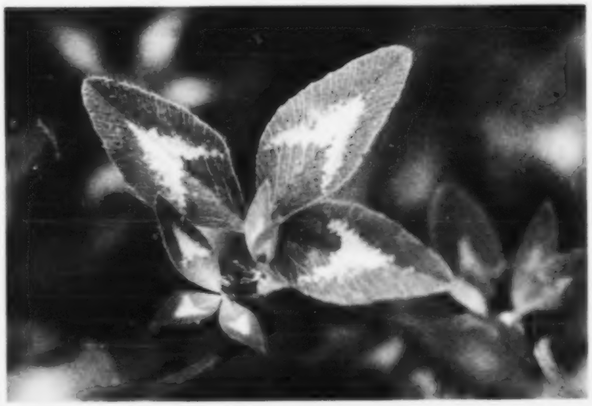
Use in Alberta

Red clover is commonly grown in the higher precipitation regions of Alberta such as on Gray Wooded soils and the more moist parts of the Black soil regions. It can be grown with grass mixtures and does well on many soils where alfalfa is not adapted. Its main limitation is poor longevity. Red clover produces high yields of hay and silage and is used in short-term pasture rotations. It is palatable and nutritious to livestock but is bloat-causing.

Red clover is a good nitrogen fixer (see Table 28 in the Forage Fertility section), which makes it very good for plow-down (green manuring). For high nitrogen addition to the soil, the crop should be worked under in the bud to early bloom stage, as more mature, bulky stands are difficult to incorporate.

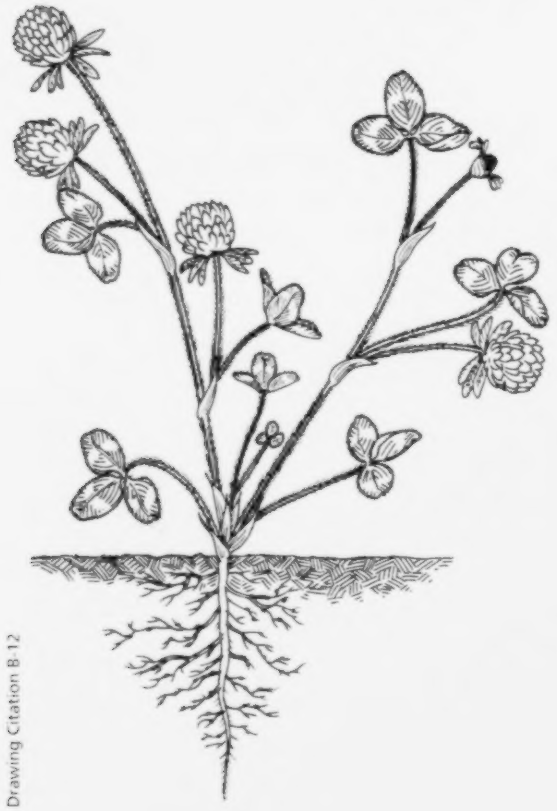
DESCRIPTION

Many upright, branched stems grow from each crown to a height of up to 75 cm (30 in.) or more. Stems and leaves of most varieties are hairy. Each leaf has three leaflets attached at a single point (palmately trifoliate), usually with a watermark (V marking) near the center of each leaflet. The stipules have dark veins.



RED CLOVER LEAF

FIGURE 13
Red clover plant and leaf



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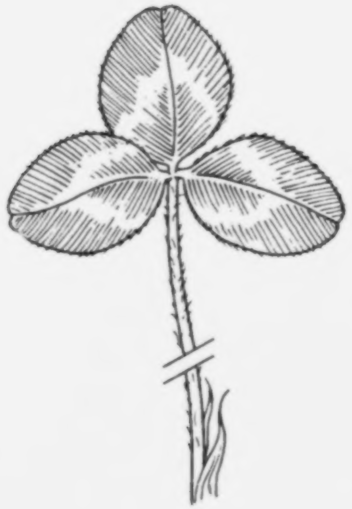

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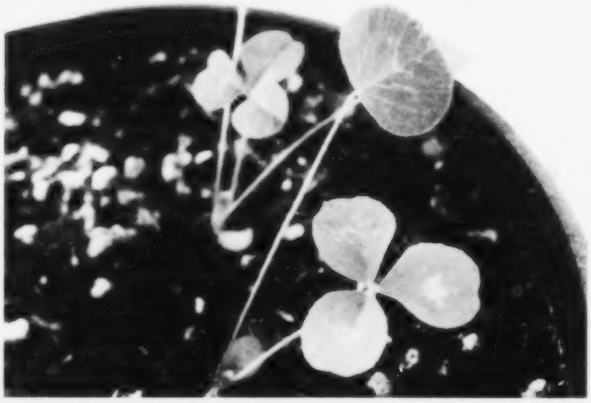
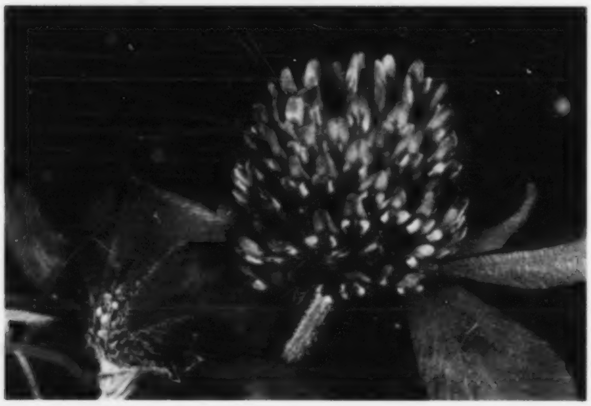
Red clover has a shallow, narrow crown and a deep taproot with many side branches. Some plants develop adventitious roots from the crowns, which makes them more persistent. Roots can penetrate soil to a meter depth or more if soil structure is favourable, but they are usually less deep. Most of the root mass is in the top 30 cm (12 in.) of soil. Red clover roots penetrate less deeply than those of alfalfa, giving it less drought tolerance. The nitrogen fixing inoculant for red clover is the same as for alsike and white clover.



RED CLOVER SEEDLING

The blossoms are in dense, terminal globe-shaped heads (racemes) with up to about 125 rose purple flowers, which are cross-pollinated. Seed pods have no stalk, are more or less oblong and are about 3 mm long. There are one or sometimes two yellow to purple seeds per pod. Hard seed content is often high.



RED CLOVER FLOWER

Red Clover

GROWTH AND DEVELOPMENT

Red clover is very easy to establish, provided moisture conditions are good and temperatures are moderate. Seedlings have good shade tolerance, are vigorous and compete well with companion crops. Single cut types mainly form a rosette of leaves in the establishment year while double cut types develop shoots. Plants that do not blossom in the seedling year have better winter survival.

Red clover produces full yield on its first utilization year (the year following establishment). It has potential for sod seeding into grass or existing red clover stands, to maintain the clover component and to extend the life of a stand.

Established red clover is fast growing, with the shoots developing from crown buds. Growing points in vegetative plants are below the top leaves, providing some protection from light grazing. Red clover has excellent regrowth ability if grazed in the vegetative stages. As hay, single cut types produce one large flush of flowering stems per year followed by vegetative regrowth. Double cut types produce two smaller flushes of flowering stems followed by vegetative regrowth. Growth is determinate and ends when a flower head is formed.

Initial spring growth and regrowth depend on energy from root storage. Root reserves begin to be replaced when there are enough leaves to photosynthesize more carbohydrates than what is needed for growth. The lowest root reserves occur two to three weeks after harvesting and the highest levels occur at or shortly after full bloom.

The cycle of carbohydrate storage in the roots is similar to that for alfalfa although reserves are lower in red clover. Cutting or grazing too frequently reduces root reserves and weakens red clover, and similar to alfalfa, fall harvesting reduces carbohydrate storage levels.

COMPETITIVENESS AND STAND PERSISTENCE

Red clover is vigorous and competitive in mixtures and is normally grown with less aggressive grasses, such as timothy.

Persistence depends on the survival of crowns. The crowns are near the ground surface and are more easily damaged than those of alfalfa. Crowns and roots tend to break down naturally in red clover, due to most nutrients being transferred to growth areas, reducing stand persistence and longevity.

Single cut red clover has good winter hardiness while double cut types have only fair hardiness. Single cut types go into winter with more dormant stem buds and more hardiness than the double cut types. Red clover is a short-lived perennial, with single cut types maintaining adequate stands for good yield for two or three production years and double cut types lasting for one or two production years.

YIELD AND QUALITY

In the more moist regions of Alberta, red clover is among the high yielding legumes for hay and pasture. It generally yields somewhat less than alfalfa for hay where both are adapted. With frequent clipping, red clover persists for only about two production years but yields very well. Quality is high, being more or less similar to alfalfa at similar stages of development. Protein and energy levels decrease quickly as the plants mature.

ADAPTATION

Red clover is adapted to cool regions of Alberta, thriving in cooler temperatures than alfalfa. It is adapted to the Gray and Black soil zones and does well on a wide range of soil textures. It grows satisfactorily on sandy soils provided there is sufficient moisture, and it does well on clay soils with poor internal drainage.

Red clover is most adapted to areas with good moisture and deep, well-drained soils with high water-holding capacity. It does best when there is adequate rainfall for the entire growing season as it has only fair drought tolerance. It will tolerate more drought stress than alsike or white clover but much less than alfalfa. Red clover has fair tolerance to excess soil moisture but is less tolerant to it than alsike clover. It is intolerant of flooding during the growing period.

The preferred pH range for red clover is slightly acidic (about pH 6.0) to neutral. It has good acid tolerance, considerably more than alfalfa or sweet clover. Red clover yields are reduced at a pH of 5.5 and much reduced at about pH 5.0. Red clover has poor tolerance to salinity.

LIMITATIONS

The greatest limitation of red clover is lack of persistence. Single cut varieties do not constitute a major portion of a stand for more than about two or three years. Double cut varieties remain productive for only one or two years in Alberta.

High moisture content and difficult curing limit the use of red clover for hay production (see Hay and Silage).

HAY AND SILAGE

Single cut types produce one large cutting with enough regrowth for fall grazing. Double cut types yield less than single cut types on the first cutting, but more on the second cutting. Cutting at first flower to about the 25 per cent flowering stage provides high quality hay. Single cut varieties are often harvested at a more mature stage to obtain the highest yields although quality is reduced. The regrowth is often grazed.

Red clover is generally upright and easy to cut, although stands sometimes lodge. Because it is very high in moisture content and high yielding, windrowed red clover is slow to dry for hay. When it is grown in a mixture with grasses, it is easier to harvest and quicker to dry. Rain after cutting causes the hay to darken in colour more than other legumes, making it appear to be of poorer quality than it is. The hairy leaves increase the dustiness of the hay.

Red clover can be ensiled satisfactorily, but high moisture content makes ensiling more difficult than for alfalfa. It needs to be wilted to ensile well.

PASTURE

It is difficult to obtain the desired proportion of red clover in a pasture since it grows profusely for one or two years and then diminishes. As little as 1 kg per hectare (1 lb/a) of red clover in a mixture will increase the yield of pasture during the first two production years.

The upright growth of red clover enables livestock to remove most of the red clover plant when grazing. It has a fair tolerance to close grazing and good tolerance to frequent grazing. Continuous close grazing is very detrimental. The crowns provide poor treading tolerance and may be damaged by cattle grazing when the soil is soft.

Red clover is more persistent with rotational grazing than with continuous grazing. Continuous light grazing may be difficult to achieve in a mixed stand due to the preferential grazing of the red clover.

Spring grazing should not, as a minimum, be initiated before a full canopy of leaves (full ground cover) develops, leaving about 10 cm (4 in.) of leafy residual for photosynthesis to enable good regrowth. A stocking period of a week or less on a given paddock avoids the grazing of new regrowth. The rest period needs to be long enough, at least four weeks with good growing conditions, for recovery before grazing again. It should be rested or grazed lightly during the four to six weeks before a killing frost, based on area averages, to allow root reserves to increase.

Red clover pasture has excellent palatability and may be grazed preferentially. Daily animal intake is high. Animal performance on red clover pasture is more or less similar to that of other commonly used legumes such as alfalfa (see Table 2). It will cause bloat in ruminants, especially in the vegetative stage, so preventative measures are required.

TABLE 2
Lamb gain during grazing (grams)

Year	Alfalfa	Birdsfoot Trefoil	Red Clover	Cicer Milkvetch
1985	243a	242a	246a	230a
1986	185a	175ab	159b	196a
1987	218b	267a	246a	247a
Mean (index)	215 (100)	228 (106)	217 (101)	224 (104)

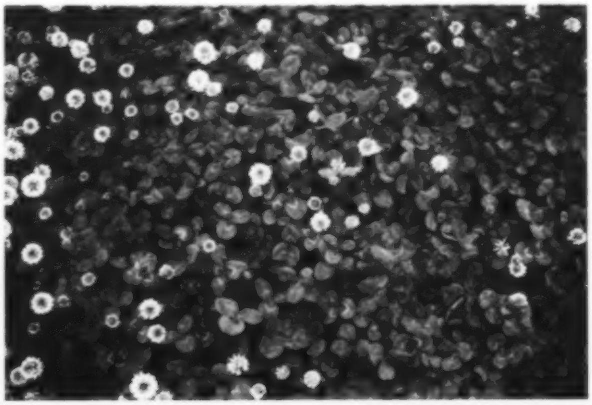
Adapted from Marten et al. 1990

Note: Figures followed by the same letter for the same year are not significantly different.

White Clover

INTRODUCTION

White clover (*Trifolium repens* L.) is native to the Mediterranean and is widely distributed in cool temperate areas of the world. It was brought to North America by early settlers and moved quickly to adapted areas, either intentionally by man or by animals. White clover is present almost everywhere in Alberta that it is adapted and appears when conditions such as moisture and close grazing make conditions right for its growth.



WHITE CLOVER PLANTS

There are three types of white clover: small, intermediate (common or white Dutch) and large (Ladino). Small white clover is found in a naturalized form wherever white clover is adapted. It grows voluntarily and aggressively when it receives sufficient sunlight. With close continuous grazing, it often dominates a stand after taller growing, higher yielding forages have been grazed out.

Intermediate types are often used as commercial pasture varieties. They yield more than the small types. Persistence is a limitation although these types may last nearly as well as the small types. Large white clover grows much taller and is much higher yielding than the others. It is larger in all aspects but is the least persistent of the white clovers.

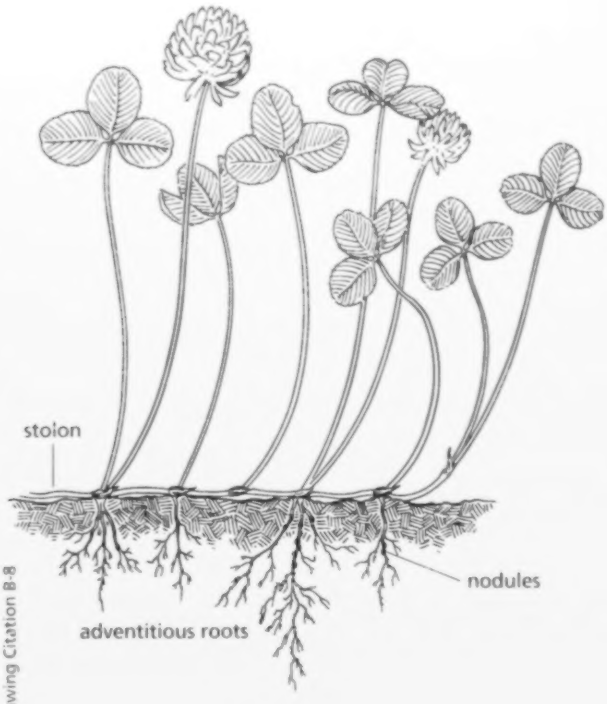
Use in Alberta

White clover is adapted to the Gray Wooded and Black soil regions and to the irrigated areas of Alberta. Small white clover is commonly found in old pastures, especially in regions with above average rainfall. It is very aggressive and spreads quickly with close continuous grazing.
The intermediate type is often seeded for pasture on Gray Wooded soils while the large type is sometimes grown in irrigated pastures. White clover is palatable to livestock although it can cause ruminant bloat.

DESCRIPTION

White clover has stolons, which are creeping stems located just above or just below the soil surface. It does not have erect stems. Leaves, flower stocks and roots grow from the stolons, which keep growing and branching repeatedly (indeterminate growth).

FIGURE 14
White clover plant and leaf



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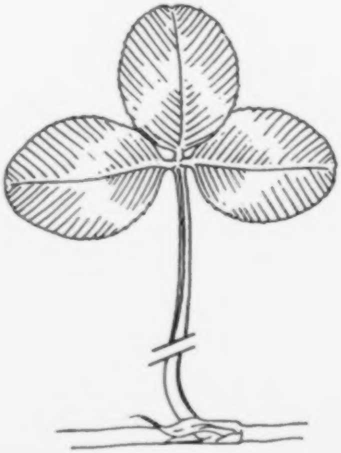

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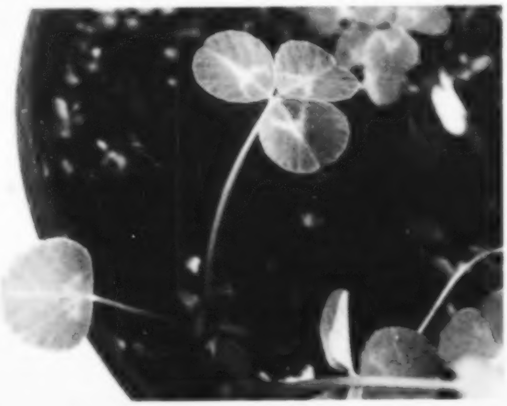
Plants are only as high as the length of the flower and leaf stalks (petioles), and height varies with type. Small types are very low growing while large types are up to about 25 cm (10 in.) or more in height. In established stands, stolons grow aggressively and can be from a few centimeters to a few meters long.



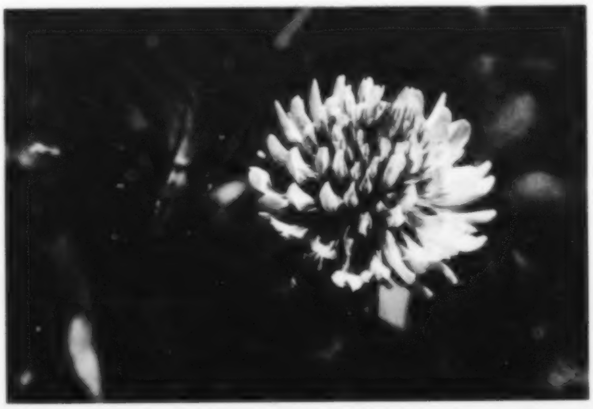
WHITE CLOVER SEEDLING

Leaves have three leaflets attached at a single point (palmately trifoliate) and are dark green, usually with a white watermark (V marking) on the upper surface. Leaflets are oval to nearly round, up to about 3 cm (1 1/4 in.) long and 2.5 cm (1 in.) wide, but are usually much smaller. They are finely toothed except near the base, hairless and have shiny undersides. The stalks (petioles) hold the leaves above ground at right angles to the sun for efficient light interception.

WHITE CLOVER LEAF

A branched taproot develops in seedling plants, but it is not long lived, leaving detached stolons as plants. The fibrous (threadlike) roots of older plants grow from the stolons and are very shallow, resulting in drought intolerance. White clover has a very low root-to-shoot ratio, the lowest of legumes grown in Alberta. The nitrogen fixing Rhizobia of white clover is in the same inoculant group as alsike and red clover.

Flower stalks are long enough to support the globe-shaped heads (compact racemes) above the level of the leaves. The flower heads can have up to 100 or more white or white with pink tipped flowers, which are cross-pollinated. Seed pods have up to four small yellow or reddish seeds, commonly having a high percentage of hard seed.



WHITE CLOVER FLOWER

GROWTH AND DEVELOPMENT

White clover has very small seeds, which require it be seeded very shallow, 6 mm (1/4 in.). Seedlings are small, develop slowly, lack shade tolerance and are not competitive. They do establish well if conditions are favourable and develop a very short shoot (rosette form) and a primary, branched taproot in the first year.

At about two months of age, seedlings begin to develop stolons, the plants become more vigorous and the stand begins to thicken. Companion crops need to be managed to minimize competition. Spring established plants can give full productivity by the year following establishment.

Initial spring growth of established white clover is not especially early. Stolon growth is indeterminate, and new leaves develop from them throughout the season as long as growing conditions remain suitable.

Regrowth occurs quickly, since grazing or cutting normally does not remove all the leaves, and the stolons are not normally grazed. In Alberta, white clover is very productive in June, July and August if growing conditions are favourable. It grows slowly in the fall.

White Clover

White clover relies mainly on existing leaves to produce energy for growth and regrowth after grazing or cutting. Energy is stored in the stolons for plants to survive winter and grow in the spring, after complete defoliation and following dormancy due to drought, etc. White clover benefits from having time to build up food reserves before the end of the growing season.

COMPETITIVENESS AND STAND PERSISTENCE

The plants grow aggressively by channeling most nutrients to the growing points near the stolon tips, while the original plant and older portions of stolons weaken and die, leaving young stolon pieces as plants. The stolons creep invasively within a stand to occupy any open spaces. Established stands of white clover are very competitive when moisture and minerals are sufficient and where other plants are low enough so that the stands receive direct sunlight.

Small volunteer types invade pastures that are kept low by frequent grazing or overgrazing. Intermediate types grow compatibly with grasses such as Kentucky bluegrass, meadow bromegrass or orchardgrass under frequent cutting, which kept stands fairly short. Large white types compete in slightly taller stands.

White clover persistence depends on the survival of stolons. Small and medium types have fair hardiness while large types have poor hardiness. White clover may die back from drought or cold and occasionally from minimal ice sheeting as stolons are vulnerable to smothering. Stands, especially volunteer types, eventually regenerate from a few surviving stolons or from seed from previous seed set.

YIELD AND QUALITY

Although white clover grows and regrows rapidly, its low growth produces modest yield, with small types generally being the lowest yielding. High quality is maintained throughout the growing season since stolons (stems) are not harvested or grazed, and new leaves are produced as long as weather is favourable.

ADAPTATION

White clover is widely adapted provided moisture is well supplied throughout the growing season. Volunteer and intermediate types grow well in the Gray Wooded soil regions and, to a lesser extent, in the Black soil regions of Alberta. Tall types can be grown in the irrigated areas of southern Alberta.

It does best on fertile soils. Clay and silty loam soil textures are most suitable as they retain moisture well. Sandy soils are suitable only if moisture is adequate.

White clover has poor tolerance to drought, and production is much affected by even short duration drought. It has good tolerance to excess soil moisture but does not tolerate water-logging or flooding for many days during the growing season.

White clover has good tolerance to soil acidity, more or less similar to alsike and red clover. The preferred pH is 6.0 to 6.5, but white clover grows and persists down to about pH 5.0. It has poor tolerance to salinity.

LIMITATIONS

White clover's greatest limitation is lack of drought tolerance. It is unproductive even during short-term drought and will succumb quickly to extreme drought. Despite favourable management, volunteer white clover will flourish or die back depending mainly on moisture conditions. The stands will eventually come back from surviving stolons or seed.

White clover may winterkill. Tall types are the least hardy, and their use is limited.

HAY AND SILAGE

White clover is not often harvested for hay or silage. Cutting in the early to 50 per cent bloom stage is satisfactory, and the feed is very digestible and high in protein. Large types grow tall enough for machine harvesting, but since white clover has no stems, leaf loss is a problem.

PASTURE

White clover has excellent tolerance to frequent, close grazing since the stolons are near ground level with growing points below the normal bite level, allowing it to be grazed closer than other legumes. Also, the stolons are spread out horizontally so that all parts of the plant are not usually grazed at one time. Many leaves and most growing points remain after grazing, enabling quick regrowth. White clover provides good tolerance to animal treading.

Low and intermediate white clover have excellent tolerance to continuous grazing while tall types benefit by rotational grazing. In a mixture, white clover benefits by grazing the grass component down in early spring and by keeping stand height low.

Initial white clover growth begins slowly in spring, but a full canopy of leaves and its full height is soon produced, after which it can be grazed repeatedly during summer. Small and intermediate white clover may be grazed leaving about 5 cm (2 in.) height of residue, while large types should be left slightly higher.

Grazing should be light enough so that stolons are undamaged, and a good portion of existing leaves remain to enable rapid regrowth. The rest period can be shorter than for most legumes, with a full canopy and height being produced in four weeks under good growing conditions. White clover should be grazed lightly during the last six weeks of the growing season but can be grazed after growth ends for the season.

White clover pasture has excellent palatability, and animal productivity is good. Livestock, especially sheep, may preferentially select for it. It is bloat-causing, and its high digestibility increases the risk of bloat.

Sweetclover

INTRODUCTION

Yellow sweetclover (*Melilotus officinalis* (L.) Lam.) and white sweetclover (*Melilotus alba* Medik.) are grown in Alberta. Sweet clover is native to Turkey. Canadian sweet clover includes varieties developed from Spanish and Siberian sources.

SWEETCLOVER PLANTS

The two species are similar except that yellow sweetclover is shorter, finer stemmed and flowers 10 days to two weeks earlier than white sweetclover. Yellow sweetclover is considered to be more drought tolerant and has more seedling vigour. In both yellow and white sweetclover, there are low coumarin varieties, which eliminate the risk of sweet clover disease.

Use in Alberta

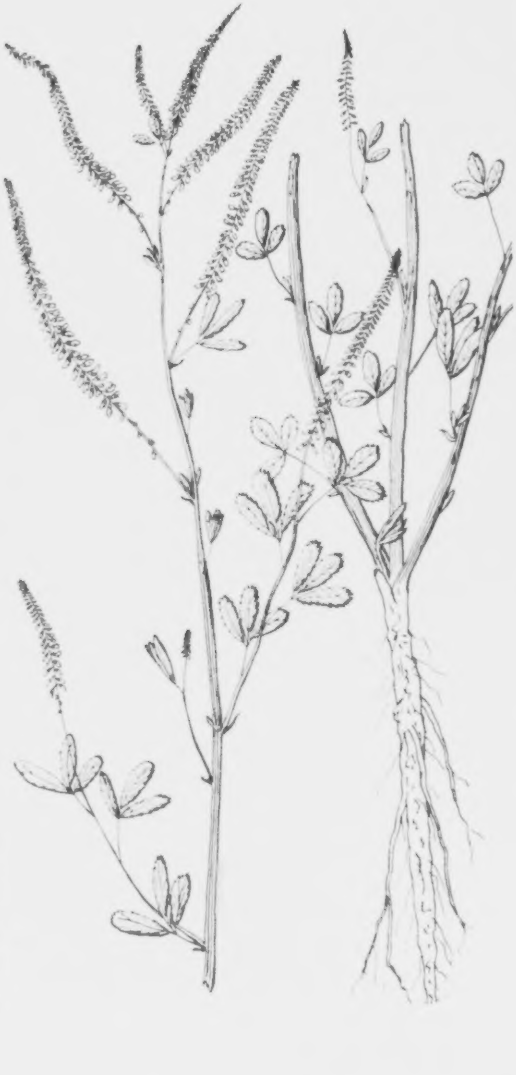
Sweetclover is a minor crop in Alberta. It is adapted to all areas of the province provided soil conditions are suitable. Yellow types are grown more than white types. Sweetclover is high yielding and can be used for hay, pasture, silage and soil improvement. Sweetclovers are biennial crops, and management is different from other forages grown in Alberta. Susceptibility to the sweetclover weevil may limit its use.

Sweetclover has high atmospheric nitrogen fixation (Table 29) and is very useful as green manure. It is usually worked under in the spring of the second year, in the vegetative stages, which will allow the top growth and roots to decompose quickly. Second-year stands that are worked under too late, resulting in a large amount of top growth, are hard to incorporate. If sweetclover is worked under in the fall of its first year or very early in its second year, it can grow back.

DESCRIPTION

Sweetclover is an upright and fast growing biennial legume. Seedling plants produce a single stem with many branches. First-year plants can reach a height up to about 0.9 m. (3 ft.) under favourable conditions. In the second year, many coarse, branched stems 1.5 m. (5 ft.) or more in height are produced from each crown.

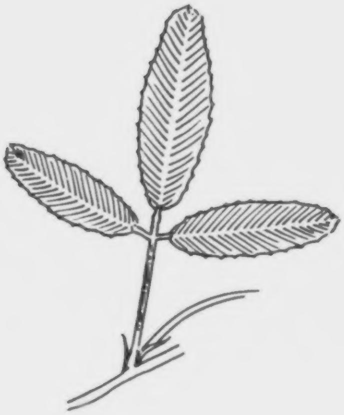
FIGURE 15
Sweetclover plant showing leaves, racemes and root



Drawing Citation F-193

Sweetclover

Leaf



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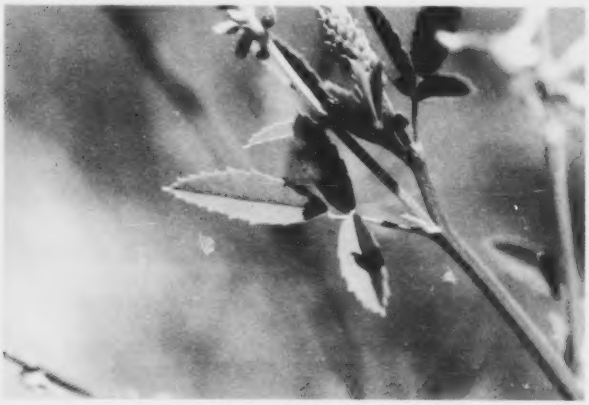
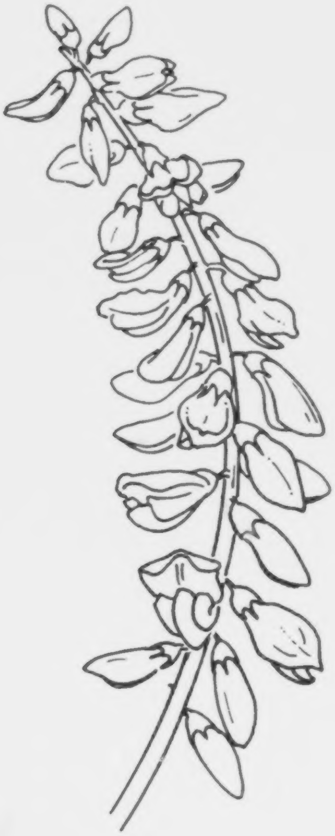
Sweetclover leaves have three oblong leaflets that can be distinguished from alsike, red, white and kura clover since the centre leaflet has a short stalk (pinnately trifoliate leaf arrangement). Sweetclover leaflets are toothed almost all around the margins compared to alfalfa leaflets, which are toothed only near the tip. Sweetclover has small narrow stipules while alfalfa stipules are broad.



SWEETCLOVER LEAF

Raceme (flowers)



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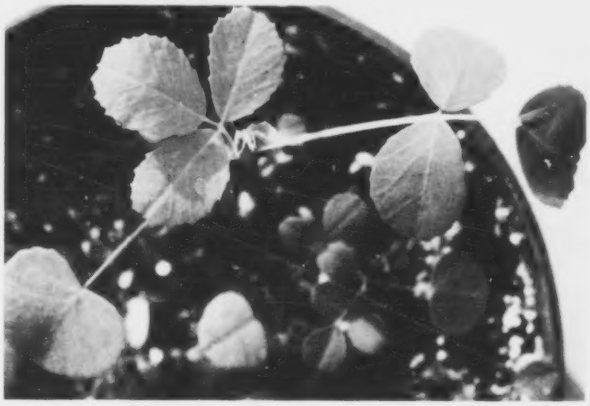
A large, very deep, widely branched taproot develops in the seedling year. The crowns are very deep set, about 3 to 4 cm (1 - 1 1/2 in.) below the soil surface, providing good protection from the winter cold. Late in the establishment year, several buds form on the crowns. These buds produce shoots in the second year.



SWEETCLOVER SEEDLING

Seedling stands do not normally flower in Alberta, but second-year stands develop long, one-sided spike-like flower clusters (racemes) at the leaf axils. Small flowers are white or yellow depending on the type, cross-pollinated and appear in early summer.

SWEETCLOVER FLOWER

WHITE AND YELLOW SWEETCLOVER FLOWERS

Seed pods are small, contain one or sometimes two yellow to brown seeds and detach easily from the plants. Yellow sweetclover seeds have purple flecks on the seed coat. Hard seed content is normally high so that scarification is needed for good germination.

GROWTH AND DEVELOPMENT

Sweetclover is easy to establish although it grows slowly during initial establishment and is not especially shade tolerant. It competes poorly with weeds and companion crops, especially under dry conditions. Seedlings grow quickly following the initial establishment period.

Sweetclover should be seeded early in spring to enable it to establish and store up root carbohydrates for good winter survival for high second-year production. Late summer to fall seeding does not provide sufficient time for establishment. Sweetclover needs the same *Rhizobia* inoculant as alfalfa to fix nitrogen.

Seedling stands can be clipped for weed control early in the season; avoid cutting lower than absolutely necessary since regrowth is from buds on stem branches. When harvesting a companion crop, producers should ensure the cutting height is high to leave the sweetclover uncut, if possible.

First-year sweetclover should not be harvested before late September as it needs to build up root carbohydrates for winter survival at this time. Later cutting or grazing in the seedling year does not affect the amount of root storage since there is little regrowth at this time of the year. Because sweetclover is a biennial, root carbohydrates are used up early in the second season and are not replaced as sweetclover is near the end of its life by midsummer of the second year.

In the spring of the second year, all the crown buds grow from below the soil surface, producing several shoots, which develop early and quickly. After cutting or grazing, regrowth is produced from buds at the branches of developed stems, mainly using energy from the existing leaves. To enhance regrowth, it is necessary that some stem and leaf material remain on the plant. Regrowth potential in the second year is limited and if conditions are not favourable, regrowth is poor, especially with yellow sweetclover.

COMPETITIVENESS AND STAND PERSISTENCE

Sweetclover seedlings lack competitive ability, but if they are well established, they have excellent cold tolerance and are very winter hardy. Second-year sweetclover is very aggressive and is usually grown alone, but it does well in mixtures with fast establishing grasses. Being biennial, it dies at the end of its second year. Sweetclover may grow voluntarily as seedlings establish from seed that sets.

WELL ESTABLISHED STAND OF SWEETCLOVER

YIELD AND QUALITY

First-year sweetclover yields can be quite high if the forage is seeded early. Harvesting before dormancy in the seedling year will reduce the yields in the second year, although total yield will be greater compared to only harvesting in the second year. Second-year yields can be very high.

Sweetclover hay in the early stages of maturity is of comparable quality to other legumes. Second-year production should be harvested early as the crop becomes very coarse and stemmy as it matures, and by full bloom, quality is greatly reduced.

Sweetclover contains coumarins with the highest amounts present in the late bud and early flower stages. Coumarin gives the plant a sweet scent but a bitter taste. Low coumarin varieties of both yellow and white sweetclover are available. These varieties contain only trace amounts of coumarin and eliminate the risk of sweetclover disease (see the section on Hay and Silage for more information).

ADAPTATION

Sweetclover is very winter hardy and is adapted to all areas of Alberta. It does best on well-drained medium-textured soils but also grows well on most sandy or clay soils. Sweetclover has excellent drought and heat tolerance. It will not tolerate flooding or saturated soils except for short periods before spring growth. Sweetclover has poor tolerance to acidity, and growth is reduced on soils having a pH of 6.0 or lower. It has good tolerance to salinity and alkalinity.

LIMITATIONS

Sweetclover is very susceptible to sweetclover weevil damage, especially during initial seedling establishment. Damage may be very high during dry years when sweetclover establishment is slow. In the second year, sweetclover develops quickly in spring, and weevil damage is seldom severe enough to affect the stands significantly.

First-year stands of sweetclover are vulnerable to the depletion of root carbohydrates from about mid-August to mid-September. Low cutting or close grazing at this time decreases future production.

Hard seeds persist in the soil for many years, so voluntary sweetclover plants can be a problem.

Refer to Hay and Silage for information on sweetclover disease.

HAY AND SILAGE

Second-year sweetclover should be cut in the bud to very early flowering stage. It should be cut high, above stem buds, if regrowth is expected.

Sweetclover stands upright and is easily harvested, provided it is cut by the early flowering stage. It is difficult to harvest at full flower or later, as the stems become tall and coarse. The stems are high in moisture content and dry slowly. By the time stems are dry, leaves are very dry and shattering is a problem. Hay conditioning enables faster drying of the succulent stems, which will reduce leaf shattering.

Sweetclover disease can be eliminated if only low coumarin sweetclover varieties are used and fields with volunteer high coumarin plants are avoided. If a high coumarin variety is harvested, care should be taken to put it up dry, without any mold. The presence of coumarin, which changes to dicoumarol (an anticoagulant) in moldy hay, causes sweetclover disease. Molds can develop under poor hay curing conditions and weathering of baled hay.

Livestock (including cattle and sheep) consuming the feed may bleed from small internal and external injuries because their blood does not clot. The disease may also cause abortions. A lab test of a representative feed sample is the best way to determine if suspect feed is safe to use. Feed containing dicoumerol may be usable but should be fed only in consultation with a veterinarian or nutritionist.

Sweetclover can be ensiled and should be cut in the early flowering stage. A short period of wilting is usually required to bring the moisture content down to about 65 per cent. High dicoumarol levels are a potential hazard if the silage is not properly covered and air is allowed to enter the silage, resulting in mold development.

PASTURE

Sweetclover is very productive as pasture if it is managed carefully from both a plant and animal perspective.

First-year sweetclover is intolerant of grazing early in the season but can be lightly grazed beginning in late September. Second-year sweetclover is intolerant of and does not regrow after close grazing. It has fair tolerance to frequent grazing.

Frequent light grazing can be accomplished with rotational grazing and the close observation of grazing height. Second-year stands should be grazed in the late vegetative stage, before stems become coarse.

Maintaining second-year plant height near 30 cm (12 in.) during the grazing season maintains stem buds and prevents plants from becoming too stemmy. If the forage gets stemmy, it should not be grazed as close to enable it to regrow from stem buds. White sweetclover is later maturing and provides a longer grazing season than yellow sweetclover. Under-stocked pasture may set seed, which results in volunteer plants in the future.

Sweetclover has fair palatability up to the bud stage, although grazing animals may select against it in a mixture. When mature, it becomes very unpalatable. High coumarin types are the least palatable, and grazing livestock needs time to adjust to them. Livestock gains are usually good.

Sweetclover is bloat-causing, and normal bloat precautions need to be taken. Sweet clover disease is not a problem when grazing live plants.

Sainfoin

INTRODUCTION

Sainfoin (*Onobrychis viciifolia* Scop.) originates from Europe and parts of Russia and Asia where it has long been used as forage. In the 1960's, it was tested extensively, and improved varieties were developed in Montana and in the southern Canadian prairies.

SAINFOIN PLANTS

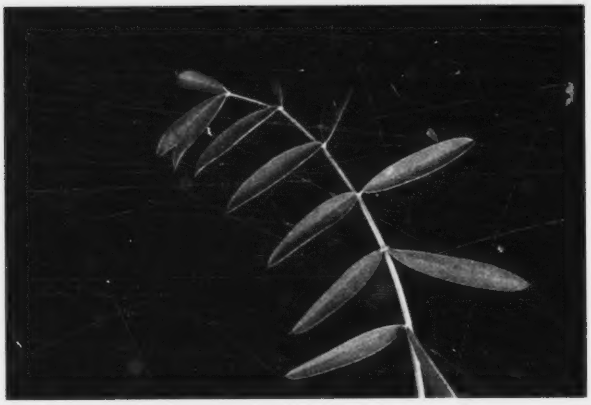
Use in Alberta

Sainfoin is used to a limited extent for hay and pasture as a pure stand or in mixtures. It is adapted to the Dark Brown soil area and irrigated areas of southern Alberta. Sainfoin has poor to fair longevity in Alberta. It is most suitable where only one cutting of hay and late fall aftermath grazing is used. For pasture it is palatable, is not bloat-causing but has poor tolerance to grazing. Being lower yielding than alfalfa, it is used to some extent to reduce the risk of bloat.

DESCRIPTION

Sainfoin is a perennial legume with erect or nearly erect stems to about 1 m (39 in.) in height growing from the crown. Stems are hollow and appear coarse, but they are very succulent. Leaves are compound with 11 to 29 leaflets. Leaflets are paired except for a single terminal leaflet (odd pinnate arrangement), and stipules are brown or reddish.

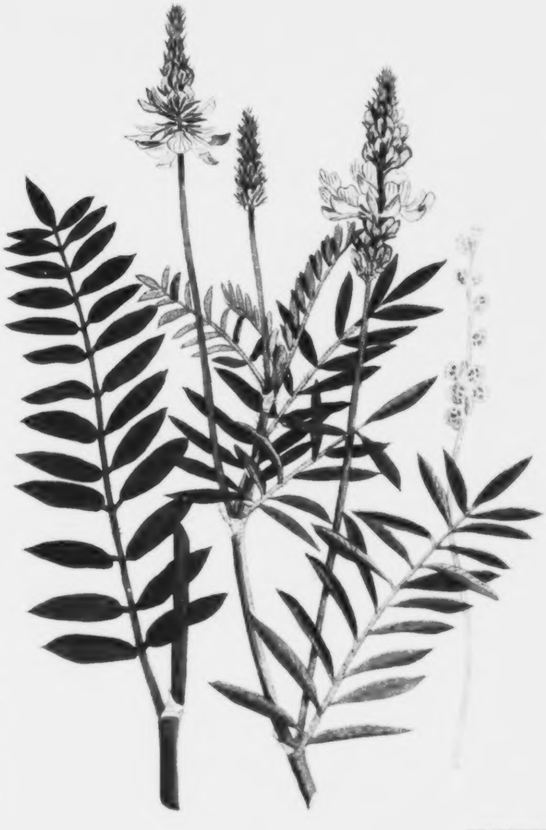
Sainfoin develops a deep, branched taproot and many fine lateral roots. The main root is very stout, and the crown is branched.



SAINFOIN LEAF

Sainfoin has long, spike-like terminal heads that are narrow at the tip and wide at the base. The heads (racemes) have up to about 80 rosy pink flowers that are attached to stalks connecting them to a common stem. Sainfoin is cross-pollinated.

FIGURE 16
Sainfoin



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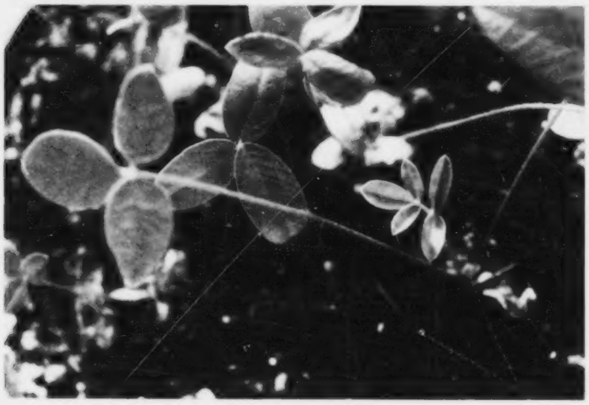
SAINFOIN FLOWER

The seed pods are tough and fibrous with a network of raised veins. The pods shatter easily from the plant but adhere tightly to the single enclosed seed, which is usually used with the pods on. The seed itself is large for a perennial forage legume with a kilogram of seed having about 48,000 seeds with pods on or 66,000 seeds with pods off. Seeds are kidney-shaped and greenish brown to dark brown. There may be some hard seeds, but scarification is not normally required.



SAINFOIN SEEDLINGS

GROWTH AND DEVELOPMENT

Sainfoin seed is large compared to other perennial legumes but does not emerge well from depth and should be planted 6 to 20 mm (about 1/4 - 3/4 in.) into the soil. Sainfoin inoculant (*Rhizobia spp.*) is different from inoculants presently used for other legumes in Alberta. Sainfoin germinates well and establishes slowly but satisfactorily. Seedlings are not competitive and do best when seeded without a companion crop. Spring-seeded sainfoin is normally well established by fall.

Established sainfoin initiates spring growth from crown buds, starts growth as early or earlier in the spring than alfalfa, grows quickly and blossoms a week or two before alfalfa. First-cut yields are good with maximum yields occurring at full bloom. It has a short blossoming and ripening period. After cutting, new branches develop from buds on the remaining stem, and regrowth occurs slowly with much less production compared to the first growth.

Sainfoin maintains minimal levels of stored carbohydrate reserves in summer and should not be cut or grazed closely as it is depends mainly on the photosynthesis of existing leaves to provide energy for regrowth. It benefits from six weeks of rest before fall frost, to build up carbohydrate storage for winter survival.

SAINFOIN

COMPETITIVENESS AND STAND PERSISTENCE

Sainfoin is not competitive. In mixtures, it does better with non-creeping grasses (bunchgrasses), such as Russian wildrye and crested wheatgrass. Total yield in mixtures with creeping rooted grasses, such as intermediate wheatgrass or smooth brome grass, is good initially, but the sainfoin is soon diminished by competition. It does not persist well in mixtures with alfalfa.

Stand persistence depends on crown survival. It persists best when seeded alone, but longevity is still only fair, and weed invasion can be a problem. Hardiness is good although the most adapted alfalfa varieties are hardier. Crown and root disease may limit sainfoin longevity.

YIELD AND QUALITY

Yield of sainfoin is typically 80 to 90 per cent of alfalfa. It yields relatively better as hay than as pasture.

Nutrient quality is excellent with digestibility about equal to that of alfalfa. Due to good leaf retention, sainfoin quality holds up better with advancing maturity than alfalfa.

SAINFOIN SEED PODS

ADAPTATION

Sainfoin is adapted to the Dark Brown soil area and irrigated areas of southern Alberta. It does best on deep, well-drained, light and medium textured soils with good water-holding capacity. It produces satisfactorily on sandy and gravelly soils with adequate rainfall.

Sainfoin has good drought tolerance and is adapted to areas normally receiving 300 mm (12 in.) or more annual precipitation. It is not tolerant of prolonged drought and does not have enough hardiness and drought tolerance for sustained production on semi-arid locations. Seedlings are very sensitive to flooding. Established plants have poor tolerance to flooding, wet soils and high water tables.

Sainfoin has poor tolerance to acidity, slightly more than alfalfa, but does best on soils with pH above 6.0. It is adapted to high calcium and has good alkalinity tolerance. It has poor tolerance to salinity.

Sainfoin seedlings and mature plants have good tolerance to spring and fall frost.

Sainfoin is resistant to bacterial wilt and the alfalfa weevil, both of which will affect alfalfa.

LIMITATIONS

Sainfoin has limited competitive ability, which often results in domination by other forages or weeds. It is lower yielding than alfalfa and has had poor stand longevity in Alberta. It is intolerant to close and continuous grazing

Sainfoin is often infected with root and crown rots that limit stand life, especially under irrigation and in higher rainfall areas.

HAY AND SILAGE

Sainfoin continues to grow up until full bloom, with good leaf retention, so that harvesting at the 50 to 100 per cent flowering stage increases yield with two cuts. In drier regions, it is most suitable for a single harvest per year.

Sainfoin grows upright and is easily harvested. It has higher moisture content than alfalfa but cures quite well for hay.

PASTURE

Sainfoin has poor tolerance to close and/or frequent grazing. It has poor tolerance to animal treading, and since stems are succulent, trampling losses can be high.

It is better suited to rotational rather than continuous grazing due to preferential grazing by livestock and the need for a long rest between grazing periods.

Grazing sainfoin at about the 50 to 100 per cent bloom stage provides maximum total yield under dryland conditions. Initial grazing in the bud stage maximizes regrowth but total yield is less. A very high residual amount should be left after grazing as sainfoin depends on existing leaves and stem buds for regrowth. Regrowth is slow. Sainfoin benefits from rest during the last four to six weeks of the growing season to build up root carbohydrates for winter survival.

Pasture and hay regrowth can be grazed in late fall when active growth has ended for the year. Leaf retention and frost tolerance are good, maintaining quality well into fall.

Sainfoin is very palatable to livestock in the vegetative and blossom stages, and it gives high daily animal production. Preferential selection often occurs, and care needs to be taken that it is not selected to the point of being lost from the stand.

Sainfoin is a non-bloat-causing legume, due to tannins in the plant, making this feature its greatest attribute for pasture. There is some research to show that having 20 per cent sainfoin in an alfalfa pasture will contribute sufficient tannins to reduce bloat substantially. Sainfoin, however, does not persist well in mixtures with alfalfa.

GRASSES

Grasses

The Grasses

Grasses have somewhat lower quality, depending on the time of utilization, compared to legumes, but exceed them in adaptation, longevity and tolerance to grazing. Many species are adapted to and grown in Alberta.

The various species each have unique characteristics that give them an advantage over other species under different growing conditions and usage. Individual grass species have superior adaptation to extreme climatic and soil factors, including high tolerance to flooding, water-saturated soil, drought, heat, cold, salinity and acidity. Many grasses are very long-lived with well established stands being more or less permanent. To determine which grasses to grow, producers must match the species and varieties with several factors: the soil climatic area and site where the grasses are grown, the intended use and the expected stand life.

For pasture, the use of forage mixtures containing at least 40 per cent grass, combined with proper pasture rotation, minimizes bloat problems. Some grasses begin growth in very cool weather and are ready for grazing in the spring, long before other forage plants. Some have higher regrowth rates that improve the distribution of production throughout summer. Most are very palatable to livestock.

The growing point of most grasses is at or below the soil surface in the vegetative growth stage and is not removed by grazing livestock. A significant percentage of the total leaf surface necessary for food manufacturing is below the grazing level. Although heavy grazing still results in low yields, grasses are more adapted to withstand grazing than legumes. Rotationally grazing grasses to allow a long rest period enables grass to regrow and restore root carbohydrates, keeping the plant strong and productive.

The root systems of grasses are fibrous, making them excellent soil binders. Some grasses also have underground stems (i.e. rhizomes) that produce new shoots at each node (i.e. joint). Rhizomatous grass stands thicken quickly, forming a dense, firm sod that competes very strongly for nutrients.

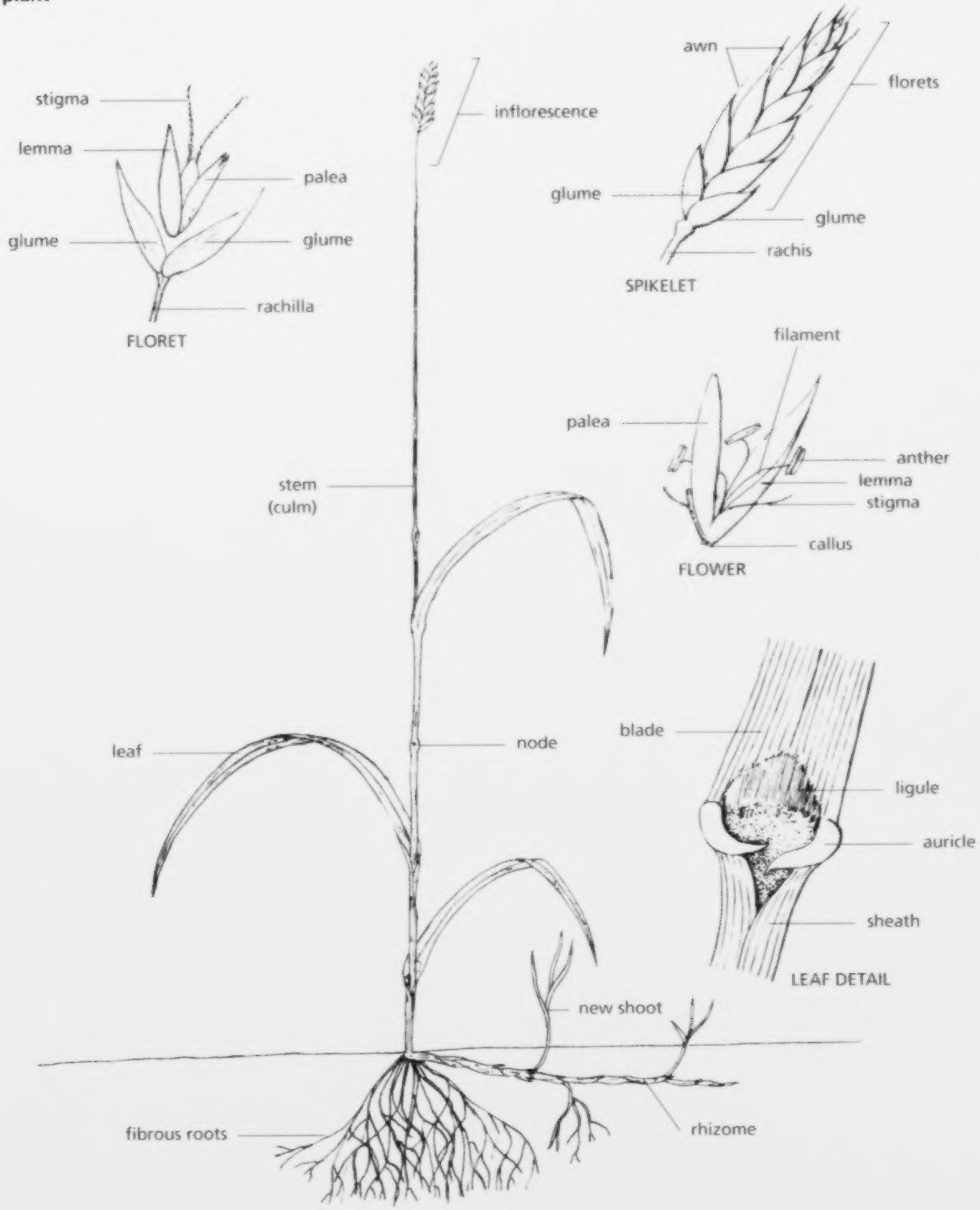
Grasses that do not have rhizomes have a bunch habit of growth. Bunch grasses do not form a thick stand, although individual plants become larger with more stems, and are not as competitive, making them more suitable in mixtures with legumes.

The stems of grasses are jointed (i.e. they have nodes) and are round or flattened in cross-section. This characteristic distinguishes them from the sedges (sometimes incorrectly called slough grass), which have triangular stems. Grasses with tall growing, leafy stems are very well suited to machine harvesting, while those with mainly basal leaves and few stems are more suited to pasture use.

Grass leaves have parallel veins and are either flat, folded or rolled. Leaf structures are very useful for species identification in vegetative stages.

The inflorescence (i.e. seed head) is usually a spike (wheat-like) or a panicle (oats-like). Almost all grasses are cross-pollinated by wind. Seeds are borne in spikelets on the inflorescence.

FIGURE 17
Grass plant


stigma
lemma
palea
glume
glume
rachilla
FLORET
inflorescence
awn
florets
glume
glume
rachis
SPIKELET
filament
palea
anther
lemma
stigma
callus
FLOWER
stem
(culm)
blade
ligule
auricle
sheath
LEAF DETAIL
leaf
node
new shoot
fibrous roots
rhizome

Drawing Citation A-75

Meadow Bromegrass

INTRODUCTION

Meadow bromegrass (*Bromus riparius* Rehm.) is native to southeastern Europe, the Caucasus, Turkey and central Asia. Collections from Turkey were developed into the cultivar "Regar" in the United States. It was released as the first meadow bromegrass variety in Canada in 1980. Since then, other varieties have been developed using Eurasian and Russian seed stock.

MEADOW BROMEGRASS PLANT

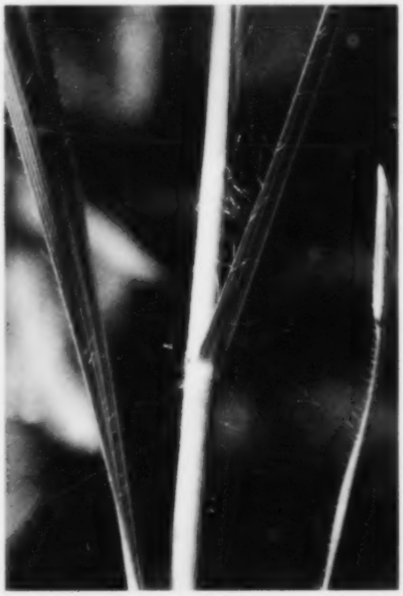
Use in Alberta

Meadow bromegrass is adapted to Black, Gray Wooded, higher precipitation areas of the Dark Brown soil zones and irrigation areas. Its range of adaptation is similar to smooth bromegrass except it is somewhat less hardy, needs better soil moisture drainage and is slightly less tolerant of salinity. It requires higher seeding rates than smooth bromegrass.

Meadow bromegrass is a long-lived perennial grass, which has mainly been used for pasture in Alberta as it regrows well after grazing, including late in the growing season. It can be grown in mixtures with legumes such as alfalfa, red clover and alsike clover.

DESCRIPTION

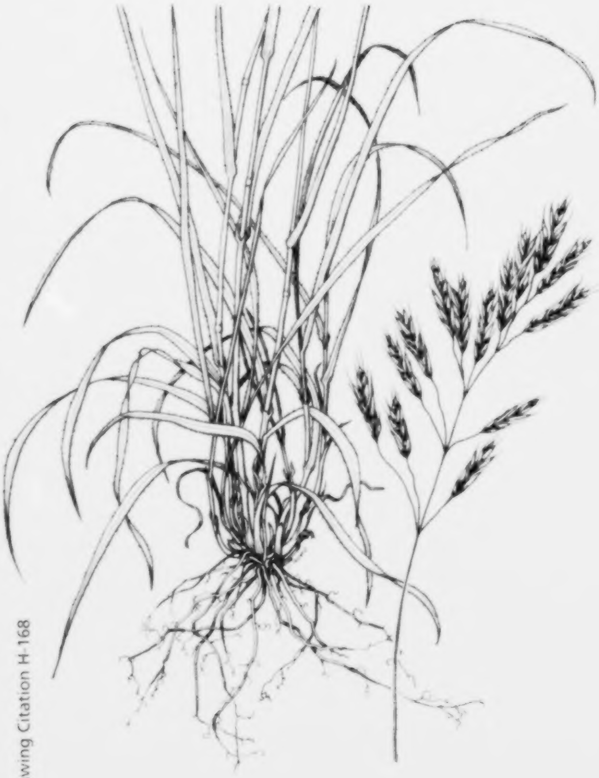
Meadow bromegrass stems are up to 1.2 m (4 ft.) in height, and the leaves are mainly basal in older stands. Leaf sheaths have long sparse hairs, and margins are grown together almost up to the leaf blades (i.e. closed sheath). Leaf blades are about 5 mm wide, long, taper to a sharp tip, lax (droop) and have long sparse hairs. There is a short ligule (1 mm) but no auricles.



MEADOW BROMEGRASS LEAVES

Meadow bromegrass has short rhizomes and creeps slowly but may have a bunch grass appearance, especially in thin stands. Individual plants become larger at the base when fully established, especially under good moisture and fertility conditions. It does not creep enough to fill in large gaps in stands when legumes in a mix die out.

FIGURE 18
Meadow bromegrass



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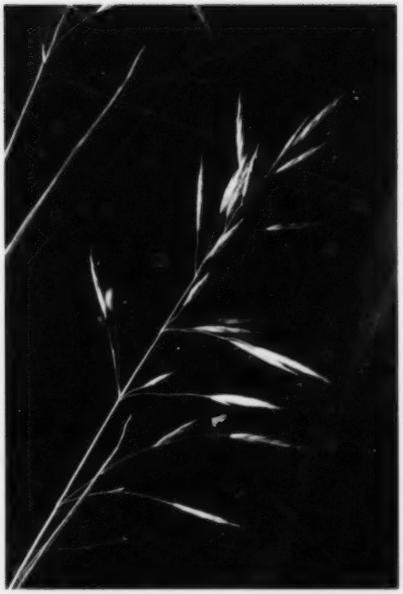


MEADOW BROMEGRASS SEED HEAD

Meadow bromegrass develops a large amount of fibrous roots, as much as smooth bromegrass (see Table 7).

Seed heads are open panicles up to about 20 cm (8 in.) long and are similar to smooth bromegrass in general appearance. Spikelets may be purple tinged and have 5 to 10 flowers, which are cross-pollinated. Seeds are large, about two thirds larger than those of smooth bromegrass. The lemmas have an awn up to 2 cm (3/4 in.) long, compared to the very short awns of smooth bromegrass. The seeds are very long and tend to bridge in seed drill boxes, especially if the awns are not removed. Commercial seed may be coated to improve its flowing ability for seeding.

GROWTH AND DEVELOPMENT

Meadow bromegrass seedling vigour is good although companion crops and weeds compete strongly with them. A higher seeding rate than smooth bromegrass is required as the seeds are larger, and the plants will not creep sufficiently to fill in gaps where establishment is poor. It is important that it be seeded to a depth of 1.5 to 2 cm (1/2 - 3/4 in.) rather than being left on the soil surface.

Meadow bromegrass begins growth very early in spring. Young stands, one to two years of age, produce a high proportion of seed heads, which develop one to two weeks earlier than those of smooth bromegrass. Older stands tend to produce mostly vegetative shoots (tillers), having a very high leaf-to-stem ratio, making meadow bromegrass well suited for pasture.

Growing points of vegetative shoots remain near ground level, and new shoots develop continually, enabling it to regrow quickly after grazing, providing a good distribution of growth throughout the growing season if moisture is adequate.

Meadow bromegrass is ready to graze in spring before orchardgrass but after meadow foxtail (see Table 3). Regrowth rate in late summer exceeds that of smooth brome, meadow foxtail and orchardgrass (see Table 3).

TABLE 3
Date grasses attained 1,570 and 2,580 kg/ha dry matter yield at Lacombe, Alberta

Species	Spring Pasture Mass 1,570 kg	Spring Pasture Mass 2,580 kg	Regrowth Yield After Cutting in Late July 1,570 kg	Regrowth Yield After Cutting in Late July 2,580 kg
Meadow brome	May 20	May 27	Aug 24	Sept 2
Smooth brome	May 17	May 25	Sept 2	Sept 12
Meadow x smooth brome	May 23	May 29	Aug 24	Sept 2
Meadow foxtail	May 15	May 24	Aug 27	Sept 13
Orchardgrass	May 27	June 6	Aug 26	Sept 6

Adapted from Baron 2004

Meadow bromegrass is compatible with legumes in a mixture. It is less competitive than smooth bromegrass in spring, but its excellent regrowth ability makes it competitive later in the season. In areas with high precipitation, volunteer Kentucky bluegrass may invade meadow bromegrass stands under frequent clipping. Stands do not become "sod bound" as they get older.

Meadow bromegrass has good hardiness and longevity, although it is less hardy than the hardiest grasses (see Table 10).

YIELD AND QUALITY

Meadow bromegrass is one of the highest yielding pasture grasses in Alberta, due to its very good regrowth ability (see Table 11) and distribution of growth (see Table 4).

As hay, meadow bromegrass produces less total yield, having a lower first cut but higher second cut compared to smooth bromegrass (see Table 5).

TABLE 4
Bromegrass simulated pasture yields at Lacombe, Alberta, 1983 – 1985 (kg/ha)

Species	Cut 1	Cut 2	Cut 3	Cut 4	Total Yield
Smooth brome	3,189	772	1,716	299	5,976
Meadow brome	2,923	1,852	1,715	982	7,473

Adapted from Baron 1986

TABLE 5
Bromegrass hay yields at Lacombe, Alberta, 1983 – 1985 (kg/ha)

Species	Cut 1	Cut 2	Total Yield
Smooth brome	7,231 (69%)	3,312 (31%)	10,543
Meadow brome	6,346 (64%)	3,503 (36%)	9,849

Adapted from Baron 1986

The quality of meadow bromegrass is similar to other grasses at the same stages of maturity. The leaves stay green well into the fall and are fairly tolerant of early frosts, making it an ideal crop to be stockpiled for dormant season grazing. Stockpiled regrowth from early July retains its nutritive value well into winter and spring with less loss of yield and quality than most grasses (see Table 8).

ADAPTATION

Meadow bromegrass is adapted to the Black, Gray Wooded and higher precipitation areas of the Dark Brown soil zones of Alberta and irrigated areas. It grows well on sandy, silty and clay soils. Meadow bromegrass has only fair tolerance of acidic soils, with highest yields from pH 6.0 to 7.5. It has only fair tolerance to salinity, slightly less than smooth bromegrass.

Meadow bromegrass has good tolerance to drought and grows more quickly after severe drought than smooth bromegrass, producing shoots (tillers) as soon as moisture is available. Under severe drought, the leaves turn brown while those of smooth bromegrass stay green, but meadow bromegrass quickly greens up when moisture becomes available.

Meadow and smooth bromegrass are suitable grasses to reduce the effects of drought in Gray and Black soil regions in Alberta. Meadow bromegrass does not have sufficient drought tolerance for dependable production in the Brown soils or the lower precipitation areas of the Dark Brown soils. Meadow bromegrass has poor tolerance to excess soil moisture in the root zone and is intolerant of surface flooding during the growing season. It has poor tolerance to spring flooding.

LIMITATIONS

Poor stand establishment, mainly due to low seeding rates and improper seed placement, has been the factor most limiting the productivity of meadow bromegrass in Alberta. Its large seed size and very slow spreading ability requires a high seeding rate to produce sufficient plant numbers for a full stand. It establishes best when seeded to a depth of 1.5 to 2 cm (1/2 to- 3/4 in.), rather than surface spreading with minimal soil incorporation.

HAY AND SILAGE

Meadow bromegrass has good suitability for dual purpose production with the first cutting being taken for hay or silage and the subsequent production for late season grazing. Since meadow bromegrass regrows well, it makes up a greater portion of the second cut yields than smooth bromegrass (see Table 5).

Cutting meadow bromegrass for hay or silage at the early blossom stage is a reasonable compromise between yield and quality for general use. Older stands produce fewer seed heads but should be cut at the same stage.

Stands of meadow bromegrass older than two or three years are mainly vegetative, with basal leaves. This characteristic makes them more difficult to harvest than upright, predominantly stem-forming grasses.

PASTURE

Meadow bromegrass is easy to manage for grazing and responds well to intensive management, making it an excellent pasture grass. It has excellent grazing tolerance and regrowth ability. Frequent close grazing is detrimental to the stand and results in low productivity. Full stands produce a dense ground cover, which provides good soil protection from treading. The tendency to lodge can increase trampling losses.

GRAZING MEADOW BROMEGRASS

Meadow bromegrass is well suited to rotational stocking. Livestock should graze paddocks quickly enough to avoid grazing new regrowth. The residual green leaves remaining after grazing should be sufficient to capture sunlight effectively (e.g. 10 cm (4 in.) height). Continuous grazing is satisfactory provided the stocking rate matches the growth rate and sufficient leaf material is present for efficient photosynthesis. Stocking rates need to be lighter for continuously grazed pastures.

Rest or light grazing in late summer and early fall increases the plants ability to store energy reserves for winter. Meadow bromegrass regrowth can be stockpiled for fall, winter and spring grazing (Table 8).

The tendency for older stands to be mainly vegetative makes for somewhat more flexibility in time of grazing compared to grasses that head out very early. Palatability is good in immature vegetative forage but decreases gradually with maturity, even if it does not head out. Like other grasses, headed forage has low palatability.

Hybrid Bromegrass

INTRODUCTION

Hybrid bromegrass was produced by crossing meadow bromegrass (*Bromus riparius* Rehm.) with smooth bromegrass (*Bromus inermis* Leyss). Smooth bromegrass (2n=56) and meadow bromegrass (2n=70) do not normally cross in the field due to differences in maturity. In the greenhouse or growth cabinet, it is possible to adjust temperatures so that these two species flower simultaneously and successfully make crosses.

HYBRID BROMEGRASS PLANTS

Initial crosses were made at the Agriculture and Agri-Food Research Centre in Saskatoon in 1976 and 1977. Many years of selection were carried out to improve the initial crosses for increased forage and seed yield, improved seed type, reduced creeping habit, improved regrowth and fall greenness.

The variety AC Knowles was released in 2000 and AC Success in 2003. Plants of these varieties have chromosome numbers ranging from 56 to 70, with many having 62 to 64, intermediate to the two parental species.

Use in Alberta

Hybrid bromegrass is a new forage, adapted to the Black, Gray Wooded, Dark Brown soil zones and irrigated areas of Alberta. Hybrid bromegrass is a dual purpose hay-pasture type of grass, producing high first-cut hay yields like smooth bromegrass and good regrowth following cutting or grazing, similar to meadow bromegrass.

DESCRIPTION

Hybrid bromegrass has some characteristics like meadow bromegrass, others like smooth bromegrass and others that are intermediate between the two species.

Stems of hybrid bromegrass may grow to a height of 1 m (3 1/4 ft.) or more and are usually slightly taller than those of smooth or meadow bromegrass. Growth is upright with some basal leaves like meadow bromegrass but having more leaves higher on the stems, like smooth bromegrass, when the plant is fully headed.

Leaves are wide like those of smooth bromegrass but are pubescent. Hybrid bromegrass has thicker but shorter hair than meadow bromegrass. Smooth bromegrass has very few leaf hairs. Leaves have a "W" constriction about midway to the tip, similar to smooth bromegrass. Leaf sheaths are closed to the top and are sparsely hairy. There is a short ligule but no auricles.

HYBRID BROMEGRASS LEAVES

Hybrid Bromegrass

Hybrid bromegrass is a cross-pollinating species that produces a spreading panicle (head). Heading often occurs in the second or third week of June, flowering close to the end of June, and seed ripening in late July. The maturity of hybrid bromegrass is intermediate to the earlier meadow bromegrass and later than smooth bromegrass. Seed yields are higher than meadow bromegrass, but lower than smooth bromegrass. Hybrid bromegrass produces more heads in older stands than meadow bromegrass.

HYBRID BROMEGRASS SEED HEAD

Seed size is intermediate to the parental species, but closer to the larger seed size of meadow bromegrass. The approximate number of seed per kg is 200,000 compared to 300,000 for smooth bromegrass and 182,000 for meadow bromegrass.

Chaffy seeds can pose problems in seeding as they bridge in some seeders and may not be evenly distributed. Mixing the seed with a denser material such as some types of fertilizer or heated grain, or having an agitation system in the seed box, minimizes bridging.

Hybrid bromegrass has good seedling vigour, so establishment is usually not a problem. Because of its large seed and reduced creeping habit, seeding rates should be higher than smooth bromegrass, similar to those used for meadow bromegrass.

Hybrid bromegrass produces short rhizomes and thus spreads much slower than smooth bromegrass. Seeded at 30 cm (12 in.) row spacings, the rows of hybrid bromegrass were still clearly visible four years after seeding, while smooth bromegrass had completely filled in the space between the rows. Hybrid bromegrass is much less invasive and competitive than smooth bromegrass when grown in mixtures.

ADAPTATION

Hybrid bromegrass adaptation is similar to smooth bromegrass and is adapted to the Gray Wooded, Black and Dark Brown soil zones and the irrigation areas of Alberta. Like other bromegrasses, it goes dormant under severe drought, but it regrows quickly when moisture returns. Hybrid bromegrass has not been tested under saline conditions, but it is expected that its salinity tolerance will be similar to smooth bromegrass.

Hybrid bromegrass is a long-lived grass, with productive stands up to ten years having been observed. Winter hardiness is good.

Hybrid bromegrass has poor tolerance to internal soil moisture drainage and only fair tolerance to acidic soils.

LIMITATIONS

Hybrid bromegrass produces more seed heads than meadow bromegrass after the third year, which makes it somewhat stemmier as a pasture grass than meadow bromegrass in more mature stands.

HAY

Although hybrid bromegrass has some basal leaf growth, it has a taller, more upright growth habit than meadow bromegrass, making it easier to cut for hay. Across all soil zones, hay yields of hybrid bromegrass have averaged about 10 per cent higher than meadow bromegrass and have been similar to or slightly lower than, smooth bromegrass. Under irrigated conditions, hybrid bromegrass yields have been high, but inferior to both smooth and meadow bromegrass. Like the other bromegrasses, hay of hybrid bromegrass generally has high forage quality and palatability.

PASTURE

In simulated pasture trials involving clipping regrowth at intervals following heading, hybrid bromegrass regrew faster and out-yielded smooth bromegrass. It was similar in yield to meadow bromegrass, showing its potential as a grazing species.

Hybrid bromegrass appears to be a highly palatable, productive species for grazing in Alberta. Hybrid bromegrass may be useful where an alfalfa bromegrass mix is seeded for hay production and used for pasture when the alfalfa begins to decline.

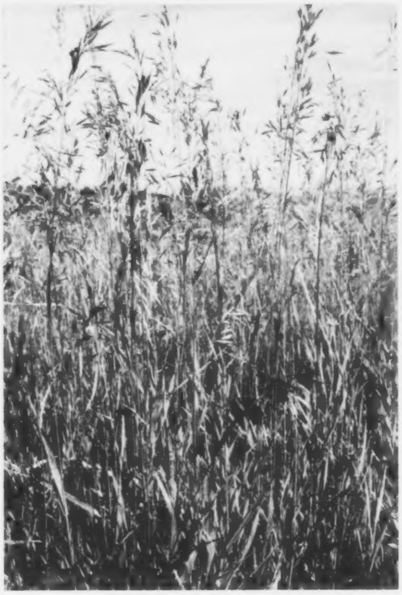
When managed as pasture, hybrid bromegrass is much like meadow bromegrass, not all tillers will be reproductive. Those that are vegetative will maintain the growing point below the grazing level, and the cut tillers will regrow. Tillers that are reproductive have elevated growing points at the stem elongation stage and are removed when grazed. These tillers will not regrow, but regrowth will come from auxiliary buds and will be slower.

Hybrid bromegrass leaves are more frost tolerant in the fall than those of smooth bromegrass but less so than meadow bromegrass.

Smooth Bromegrass

INTRODUCTION

Smooth bromegrass (*Bromus inermis* Leyss.) is native to Europe, Russia and northern Asia. Early northern types came into Canada from Germany while southern types were from France and Hungary.



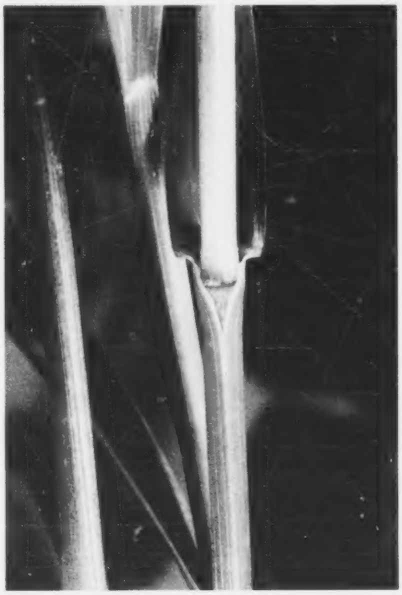
SMOOTH BROMEGRASS PLANTS

Northern types of smooth bromegrass produce more seed, are less strongly creeping and are well adapted across the province. Southern types have superior seedling vigour, drought tolerance and regrowth after cutting or grazing. Southern types are generally the best adapted in the United States and some are suitable in Alberta. Intermediate types combine some traits of both. Variety selection should be made on the basis of regional performance and adaptation.

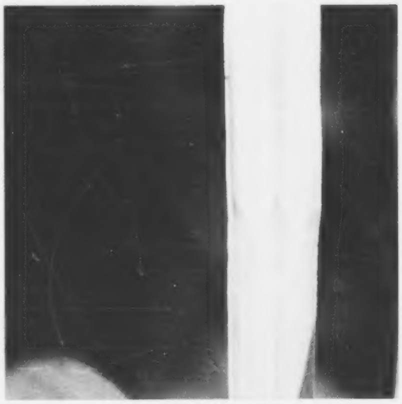
Use in Alberta
Smooth bromegrass is adapted to the parklands and much of the prairies, including the Black, Gray Wooded, Dark Brown soil zones and irrigated areas of Alberta. It is the most used tame grass for hay and is the most common grass growing along roadsides and in waste areas in central and northern Alberta. It is very palatable to livestock when used for pasture, but it regrows slowly. Smooth bromegrass is very aggressive, has excellent cold tolerance and is long lived.

DESCRIPTION

Smooth bromegrass stems are erect and leafy, commonly reaching a meter in height but may grow to as high as 1.2 m (4 ft.). The leaf sheaths are mainly hairless but may have some hair on the lower parts, and the margins are closed up to the leaf blade. Leaf blades are rolled in the sheaths. The blades are nearly hairless, flat, wide (up to about 1.5 cm (1/2 in.). wide) and taper to a sharp tip. Smooth bromegrass often has a "W" shaped constriction near the middle of the upper leaf surface, which can aid in its identification. There is a very short ligule but no auricles.

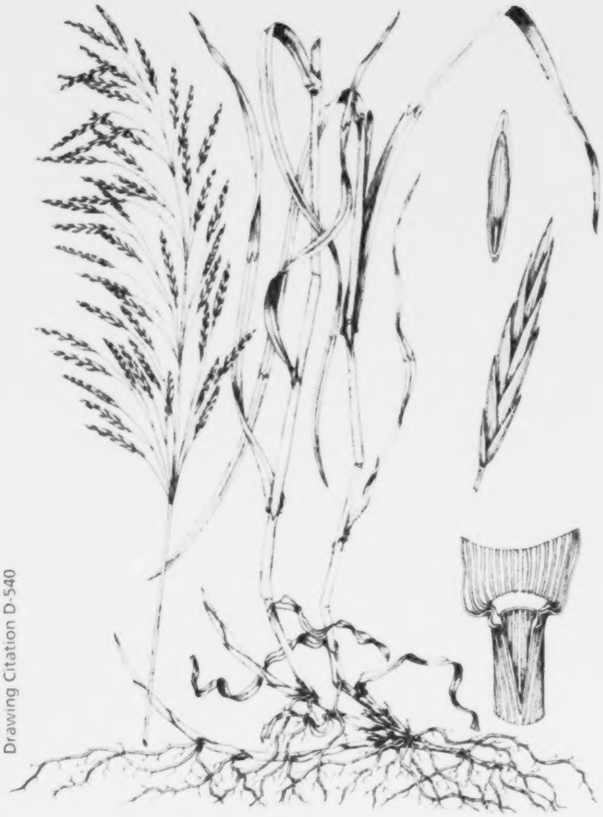


SMOOTH BROMEGRASS LEAF



W-SHAPED LEAF CONSTRICTION

FIGURE 19
Smooth bromegrass



Drawing Citation D-540

Smooth bromegrass has very fine, fibrous, deep roots. It can draw on soil moisture reserves at greater depths than many grasses (Tables 6 and 7). It develops long rhizomes (creeping roots) once it is established, enabling it to spread aggressively so that thin stands will thicken up. Rhizomes are also important for carbohydrate storage and form a dense sod.

TABLE 6
Percentage and total grass root distribution on shallow soil

	% of Roots at Each Soil Depth (cm)					Total
Grass	0 - 7.5	7.5 - 15	15 - 22.5	22.5 - 30	30 - 45	kg/ha (lb/ac)
Smooth Bromegrass	51%	14%	10%	9%	15%	4,688 (4,186)
Orchardgrass	80%	8%	5%	3%	4%	5,236 (4,675)
Kentucky Bluegrass	88%	7%	4%	0.5%	0.5%	4,292 (3,832)
Timothy	89%	5%	3%	2%	2%	2,572 (2,296)

Adapted from Gist and Smith 1948 (in eastern United States)

TABLE 7
Root mass of grasses in soil versus grazing intensity at Lacombe, Alberta (kg/ha)

Species	Soil Depth	Grazing Intensity Light	Medium	Heavy
Smooth Bromegrass	0 - 30 cm	1,390	2,020	1,720
Smooth Bromegrass	0 - 60 cm	2,840	3,520	3,120
Meadow Bromegrass	0 - 30 cm	2,610	2,090	1,540
Meadow Bromegrass	0 - 60 cm	4,890	3,730	3,320
Triticale	0 - 30 cm	530	800	480
Triticale	0 - 60 cm	940	1,320	810

Adapted from Mapfumo et al 2002 (Lacombe)

Smooth bromegrass heads are erect panicles up to about 20 cm (8 in.) long with somewhat ascending branches. Spikelets usually have 7 to 10 flowers, which come into blossom for a week to ten days and are cross-pollinated.

The seed develops quickly once it is pollinated and is purplish brown at maturity. Seeds are long (±1.2 cm (1/2 in.)) and narrow, and the lemmas occasionally have a short awn. Smooth bromegrass seeds easily bridge in seed drills making it difficult to meter out the correct seeding rate. Seed may be coated to improve its flowing ability when seeding.

SMOOTH BROMEGRASS SEED HEAD

GROWTH AND DEVELOPMENT

Smooth bromegrass seed needs good soil coverage, germinates quickly and has good seedling vigour, but establishes slowly. Once established the rhizomes develop and spread, thickening the stand, although full yield potential is frequently not reached in its first production year.

Growth of smooth bromegrass is rapid in early spring during its initial flush of growth (see Tables 4 and 11), developing leafy stems with and without seed heads. Regrowth is vegetative and leafy, but develops slowly making for a poor distribution of growth over the season (see Tables 3 and 4).

Smooth bromegrass grows well in mixtures, but it is very aggressive and competitive with other forages because of its strong creeping habit, vigour and tall growth. It is invasive and can encroach into native pastures, especially if they are in poor condition. It is easily removed from cultivated fields when tillage and herbicides are used.

Smooth bromegrass is often seeded in mixtures with alfalfa. Smooth bromegrass dominates alfalfa early in the growing season, but alfalfa competes well later in the season because of its ability to regrow. Smooth bromegrass usually increases in the stand and dominates the mixture within three or four years. This problem can be reduced by seeding less smooth bromegrass initially and fertilizing to favour alfalfa.

Older stands of smooth bromegrass that have no legume companion or nitrogen fertilizer applied have smaller tillers and roots and low productivity. These stands are generally considered to be "sod bound" and can normally be rejuvenated through fertilization (see Rejuvenation section).

Smooth bromegrass has excellent cold tolerance (see Table 10), persistence and longevity.

YIELD AND QUALITY

Smooth bromegrass is among the highest yielding grasses in Alberta provided it has a good supply of nutrients, especially nitrogen. Its high yield is based on a one or two-cut harvesting system, making it most suitable for hay and silage (see Table 5).

Pasture yields of smooth bromegrass are considerably less than for hay. At Lacombe, it yielded 43 per cent less with a 4-cut pasture regime than with a 2-cut hay regime (see Tables 4 and 5).

Because smooth bromegrass is leafy, quality is good for pasture in immature stages and good for early cut hay, but it declines quickly after heading as the forage becomes stemmy and coarse.

ADAPTATION

Smooth bromegrass is most suited to the Gray Wooded, Black and Dark Brown soil zones. It is adapted to irrigated areas and does well in areas with limited availability of irrigation water.

Smooth bromegrass is adapted to sand, silt and clay soils. It produces the highest dry matter yields on deep, fertile silt loam or clay loam soils that are well drained. It does well on sandy soils if there is sufficient moisture. Smooth bromegrass has fair tolerance of acidic soils and is most productive on soils with a pH of 6.0 to 7.5. It has good salt tolerance.

Smooth bromegrass has good drought tolerance, considerably more than timothy and orchardgrass but less than crested wheatgrass. Smooth and meadow bromegrass are suitable grasses to reduce drought effects on Gray Wooded and Black soils in Alberta.

Both seedling stands and established stands of smooth bromegrass have good tolerance of spring flooding. It has fair tolerance of excess soil moisture in the root zone.

LIMITATIONS

Smooth bromegrass is very aggressive and often dominates legumes in mixtures. This characteristic limits its usefulness. The problem can be diminished by fertilization that favours the legumes.

Smooth bromegrass regrows slowly, resulting in a poor distribution of growth and limiting its usefulness for pasture.

HAY AND SILAGE

The first cut of smooth bromegrass is high yielding and has excellent suitability for hay and silage making. The regrowth develops slowly, does not head out and is low yielding for hay or silage, but provides good pasture. Growing smooth bromegrass in a mixture with a legume, such as alfalfa, provides good second-cut yields as long as the legume is maintained in the stand.

The early heading to early blossom stage provides good yield and quality. The second cutting should be timed, so there is at least 15 cm (6 in.) of growth at the time of killing fall frosts. Mixtures should be harvested at the correct stage for legumes.

The first cutting of smooth bromegrass grows upright, is lodging resistant, easy to harvest as hay or silage and is easily cured for hay. A cutting height of 10 cm (4 in.) is satisfactory.

PASTURE

Smooth bromegrass is less suited to pasture production than to hay production. Its early season yield is good, but it regrows slowly and other grasses produce more late in the grazing season (see Table 3). It is very tolerant of grazing but is unproductive under long-term frequent, close grazing. The sod provides good soil protection from treading.

Smooth bromegrass is most productive with rotational grazing since it needs a long rest period to regrow.

It tolerates continuous grazing but must be stocked with fewer animals since it is less productive. It benefits from rest or light use in late summer so that carbohydrates can accumulate for winter. Stockpiled forage can be grazed in late fall or early winter. It may have low digestibility after wintering over in the field and is not suited for dormant spring grazing (see Table 8).

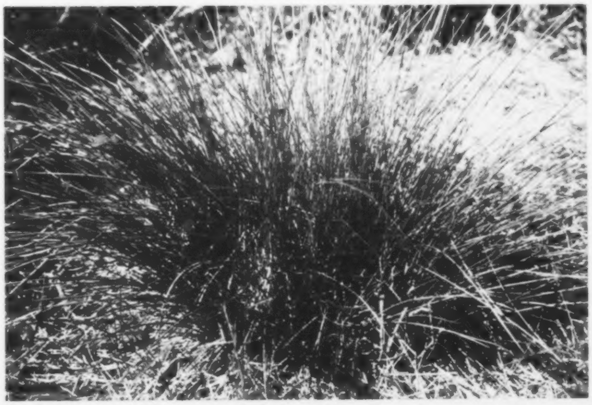
For best regrowth, the initial spring growth of smooth bromegrass should be grazed before stem elongation occurs. It should be grazed evenly but not too closely to a minimum of about 10 cm (4 in.) in height. Smooth bromegrass in the vegetative stage has excellent palatability for grazing livestock although once it has headed, palatability is low.

VEGETATIVE STAGE OF SMOOTH BROMEGRASS

Creeping Red Fescue

INTRODUCTION

Creeping red fescue (*Festuca rubra* L.) is native to Europe and North America. Early introductions into Canada were from Czechoslovakia. Boreal creeping red fescue was licensed in 1966 and is presently the main variety used for hay and pasture in Alberta.



CREEPING RED FESCUE PLANT

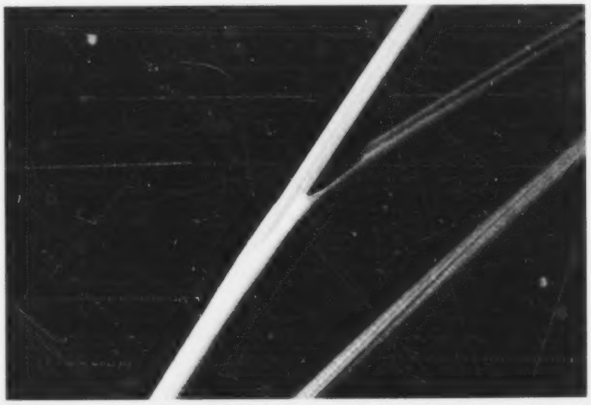
Red fescues are fine-leaved fescues. The creeping red fescue used for agricultural purposes in Alberta is mainly of the strongly creeping type. There is an intermediate type which has shorter rhizomes and less spreading ability. Chewings fescue (*Festuca rubra* L. ssp. *fallax* Thuill.) is a non-creeping red fescue. It is finer and lower growing than creeping red fescue and is used for turf purposes.

Use in Alberta

Creeping red fescue is a long-lived perennial grass that is often used for pasture in moist regions of Alberta. It produces modest yields and is adapted to the Gray Wooded soil region and the higher precipitation areas of the Black soil region. It maintains quality when dormant and can be used to extend the grazing season into fall and winter. This grass is also useful for turf and soil stabilization. It is an important seed crop in northern Alberta.

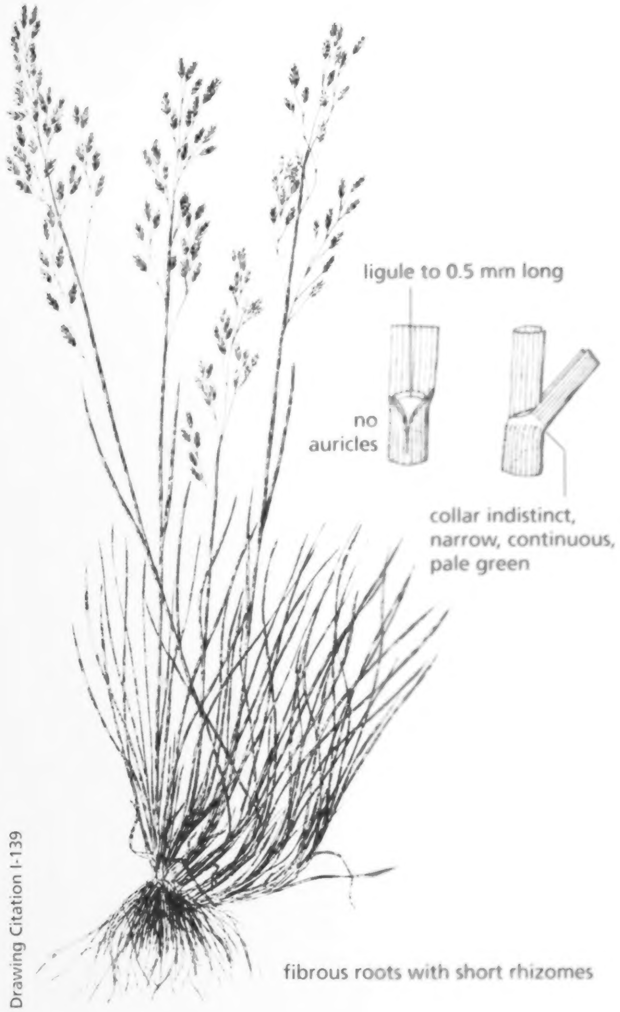
DESCRIPTION

Creeping red fescue is low growing with erect stems up to 80 cm (32 in.) or more in height with very few stem leaves. Well established dense stands have an abundance of basal leaves with very few stems. The leaf sheaths are open at the top, finely pubescent (hairy) and are reddish at the base of the shoots, just above ground level. Leaf blades are hairless, bright green, up to about 30 cm (12 in.) long and are narrow (3 mm wide) with pointed tips. When moisture is limiting the leaves are tightly rolled. Open leaves are prominently ridged on the upper surface but smooth and shiny on the bottom surface. Auricles appear only as slight swellings on the leaf collar, and there is a very short ligule (0.5 mm).



CREEPING RED FESCUE LEAF

FIGURE 20
Creeping red fescue


ligule to 0.5 mm long
no auricles
collar indistinct, narrow, continuous, pale green
fibrous roots with short rhizomes

Drawing Citation I-139

Creeping red fescue has an extensive fibrous and fairly deep root system. Rhizomes enable it to spread although it is not as aggressively creeping as smooth bromegrass or Kentucky bluegrass. It develops a strong sod.

The seed head is a narrow panicle up to about 15 cm (6 in.) or more in length, intermediate in size between smooth bromegrass and Kentucky bluegrass. Spikelets have four to six flowers, which are cross-pollinated. Spikelets may be purple tinged, and the lemmas have awn tips or short awns. Seeds of strongly creeping red fescues are larger than those of other red fescues.

CREEPING RED FESCUE SEED HEAD

GROWTH AND DEVELOPMENT

Seedling vigour is good, and the forage establishes well under favourable growing conditions. If companion crops are used, they should be managed to reduce competition for best establishment.

Young stands tend to produce a high percentage of shoots with seed heads while older stands are mainly vegetative with basal leaves. Creeping red fescue begins spring growth later in spring than most other grasses but has excellent regrowth through to late fall. Growing points remain below the normal bite level of grazing livestock in vegetative shoots.

Creeping red fescue is fairly competitive with other forages. It has good shade tolerance and persists well as a bottom grass in mixtures. It is often seeded with timothy and alsike clover in the more moist parts of the province and with smooth bromegrass and alfalfa in central Alberta. With close, continuous grazing, it will go out of the stand, often being replaced by volunteer Kentucky bluegrass.

Creeping red fescue has excellent longevity and winter hardiness (see Table 10).

YIELD AND QUALITY

Creeping red fescue yields are modest, similar to Kentucky bluegrass for pasture but less than meadow bromegrass or orchardgrass (see Table 9).

Digestibility and protein of creeping red fescue are typical for grasses grown in Alberta, but the forage retains higher nutritive value into the dormant season compared to other forage species. Regrowth from early July provided the highest quality of several grasses in late fall and through to the following spring, after wintering on the stem (see Table 8).

ADAPTATION

Creeping red fescue is adapted to the Gray Wooded soil region and higher precipitation areas of the Black soil region of Alberta. It can be grown on a wide range of soil textures, including clay, silt and sand provided there is sufficient moisture. Creeping red fescue has excellent acid tolerance, withstanding pH levels of 4.5. It has good tolerance of salinity.

Creeping red fescue has fair drought tolerance, more than timothy, but yields are very low under dry conditions. It thrives under cool, moist conditions and has good tolerance of flooding and excess moisture in the root zone. It has good shade tolerance and is able to grow under the canopy of taller forages.

Lawn seed mixtures commonly include creeping red fescue as a component with Kentucky bluegrass. It has fine leaves and stays green over a long season. As a turf, it is very durable and is useful for lawns, farmyards, playgrounds, etc.

Creeping red fescue is frequently included in mixtures with other grasses for reclamation purposes. It is useful for seeding roadsides, rights-of-ways, industrial sites, etc. where its low growth and good cover are very desirable. Good moisture tolerance makes it useful along ditches.

TABLE 8
Dormant season quality of forage regrowth following a mid-July harvest at Lacombe, Alberta, 1998 – 2000

	Harvest Dates							
	Oct 15	Apr 15	Oct 15	Apr 15	Oct 15	Apr 15	Oct 15	Apr 15
Species	**Protein (%)**		**NDF (%)**		**IVDOM (%)**		**DM Yield (kg/ha)**	
Meadow Bromegrass	8.0	9.9	57.2	72.2	57.9	50.5	5,780	4,520
Smooth Bromegrass	6.7	9.6	62.7	77.8	55.3	37.3	6,100	4,110
Orchardgrass	7.9	10.5	59.0	72.9	57.2	42.7	5,640	4,380
Timothy	7.1	9.8	58.9	73.9	55.8	40.9	7,040	6,840
Crested Wheatgrass	7.5	7.4	55.7	70.2	58.3	47.5	6,790	4,440
Kentucky Bluegrass	10.3	10.7	61.1	71.6	52.8	44.0	4,340	4,040
Creeping Red Fescue	8.2	10.0	49.9	64.4	59.7	49.5	5,060	3,460

NDF = Neutral Detergent Fiber
IVDOM = Invitro Digestible Organic Matter
DM = Dry Matter

April harvest was forage wintered "on the stem" in the field.

Adapted from Baron et al 2004

LIMITATIONS

Creeping red fescue is low growing with modest yields and is not well suited to hay production. It is grazing tolerant but does not tolerate continuous close grazing. It is susceptible to snow mold.

HAY AND SILAGE

Creeping red fescue is low growing with modest yields and is not well suited to hay and silage production. It is useful in hay/pasture mixtures as it tolerates shade and persists fairly well with taller growing forages, which can be hayed and the regrowth grazed.

PASTURE

Creeping red fescue is best suited to pasture production. It has good grazing tolerance as its low growth results in a high percentage of the leaf material below the normal grazing level. It is not tolerant of continuous close grazing and is often grazed out of stands, usually being replaced by volunteer Kentucky bluegrass in more moist regions. The sod supports livestock well and is resistant to treading.

Creeping red fescue is suitable for either rotational or continuous grazing, provided stocking rates are matched with productivity. It has excellent regrowth and can be grazed more frequently than some tall growing species, such as smooth bromegrass or timothy. A minimum of about 5 cm (2 in.) of leafy residue should be left after rotational grazing.

Creeping red fescue is useful for dormant season grazing in fall and early spring grazing before new growth begins. If creeping red fescue is to be used for stockpiled winter grazing, no grazing or cutting should occur after early to mid-July to allow for sufficient regrowth for dormant season grazing (see Table 8).

The regrowth following seed harvest can be moderately grazed in fall.

WINTER OR DORMANT SEASON GRAZING
OF STOCKPILED FORAGE

Meadow Fescue

INTRODUCTION

Meadow fescue (*Festuca pratensis* Huds.) is of European origin. Some is grown in eastern Canada, mainly for pasture on land with poor drainage. It has been replaced by tall fescue in the United States.

MEADOW FESCUE PLANT

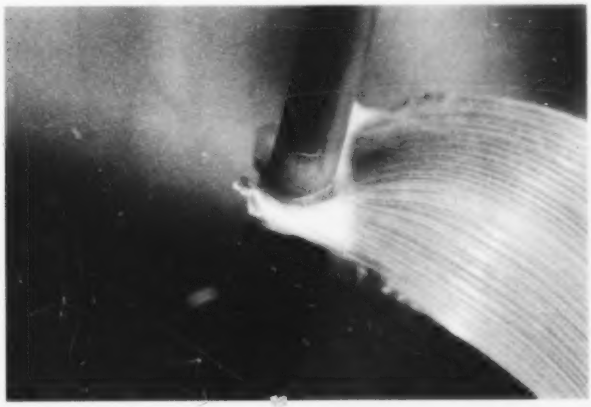
Meadow fescue, a diploid, is closely related to tall fescue, which is a hexaploid. The two grasses are very similar in adaptation and appearance and are difficult to distinguish from each other. Meadow fescue is less coarse, shorter, has narrower leaves, shallower roots and is not as persistent as tall fescue. Meadow fescue is generally considered to be less productive than tall fescue although this feature may depend on environment and variety. Meadow fescue is also closely related to perennial and annual ryegrass and can be crossed with them.

Use in Alberta

Meadow fescue is a minor grass in Alberta. It is adapted to high precipitation areas and is used for pasture and hay. The lack of cold hardiness has been a limitation.

DESCRIPTION

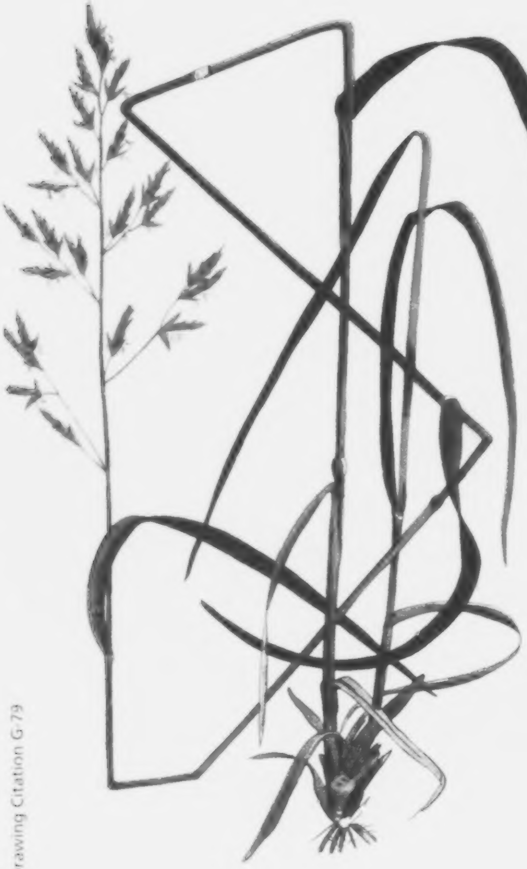
Meadow fescue grows erect, with stems to about 1 m in height with mainly basal leaves. Leaf sheaths are hairless, have overlapping margins and are reddish purple at the base of the shoots. Leaf blades are 5 to 8 mm wide, hairless, with veins showing on the upper surface, the undersides are distinctly glossy and the edges (margins) are rough. Leaves have blunt auricles and a short ligule, up to 0.5 mm long.



MEADOW FESCUE LEAF

Minor vegetative differences can be used to differentiate meadow fescue from other closely related fescues and ryegrasses. Meadow fescue has no hair on the auricles or on the margin of the collar while on tall fescue, they are visible on new leaves. Meadow fescue has shorter ligules and rough edges on the leaf blades compared to Italian ryegrass. Meadow fescue leaves are rolled in the bud stage while those of perennial ryegrass are folded.

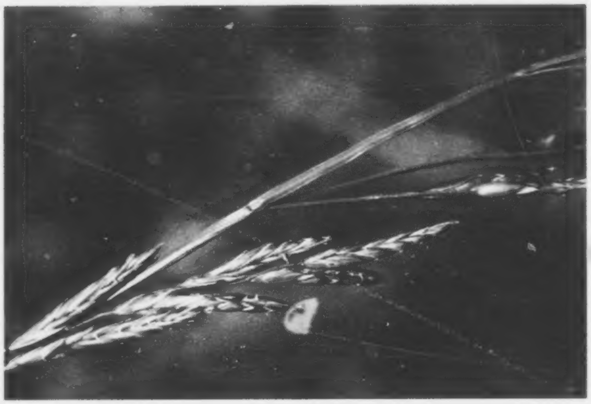
FIGURE 21
Meadow fescue



Drawing Citation G-79

Roots are fairly deep, tough and are coarse for a grass. It has short non-creeping rhizomes, and it may appear somewhat tufted or bunched. It is often considered to be a bunch grass. In well established stands, it forms a light sod.

The head (inflorescence) is a panicle which is 10 to 20 cm (4 to- 8 in.) long. Spikelets have 6 to 10 flowers, which are cross-pollinated. Lemmas are awnless or short awned.



MEADOW FESCUE SEED HEAD

GROWTH AND DEVELOPMENT

Meadow fescue has medium seedling vigour and establishes satisfactorily, usually in one growing season. It benefits from management that reduces competition from other crops and weeds.

MEADOW FESCUE PLANTS

The regrowth ability of meadow fescue is good, providing a fairly good distribution of growth, and it is a good pasture grass. As hay, it produces a good first cut with regrowth suitable for fall grazing.

Meadow fescue is fairly competitive once it is well established and is compatible in mixtures. It has only fair winter hardiness and longevity.

YIELD AND QUALITY

New meadow fescue stands yield quite well although productivity often decreases by the third year. This forage tends to be less productive than tall fescue. Growth is good in summer and fall provided moisture conditions are favourable. Quality is good. It is suited to stockpiling for fall use as vegetative material maintains quality into fall.

Meadow fescue can have an endophyte that lives in the plants without changing their appearance, as for tall fescue. It is not known what effect the endophyte has on this grass, but it is not thought to affect palatability or cause feed toxicity.

ADAPTATION

Meadow fescue is adapted to the higher precipitation regions of areas 3, 4, and 5, and the irrigation areas of Alberta, although hardiness may limit its use (see Figure 1 in the soil climatic areas in the Forage Adaptation section). It has wide soil adaptation but does best on silt or clay soils that are fertile and moist. It will grow satisfactorily on sandy soils if moisture is not limiting. It has good tolerance to clay soils with poor internal drainage and is adapted to peaty soils. Meadow fescue has good acid tolerance, growing satisfactorily on soils with a pH at or below 5.0, but it does best on soils that are not extremely acidic. It has good tolerance to salinity.

Meadow fescue has fair drought tolerance but is considered to be slightly less tolerant than tall fescue. It has good tolerance to flooding and excess soil moisture in the root zone.

LIMITATIONS

Meadow fescue has only fair hardiness, and winter injury may delay initiation of spring growth, affecting stand productivity.

HAY AND SILAGE

Meadow fescue should be harvested by early heading. It is suitable for hay although its leaves are mainly basal. It regrows well for fall grazing.

PASTURE

Meadow fescue is best adapted for pasture. It has good regrowth and good grazing tolerance. Strong roots and short rhizomes give it good treading resistance.

Rotational grazing is the most productive use of meadow fescue although continuous grazing is satisfactory, provided stocking rates are matched to production and residual requirements. A minimum of about 10 cm (4 in.) of leafy residue should be left after grazing. It can be stockpiled and grazed in late fall and early winter.

Tall Fescue

INTRODUCTION

Tall fescue (*Festuca arundinacea* Schreb.) originated in Europe and North Africa. Early Canadian seed originated from England and Germany, but came from the United States, where it is used mainly in states in the transition zone where both northern cool season and southern warm season grasses are grown.

TALL FESCUE PLANT

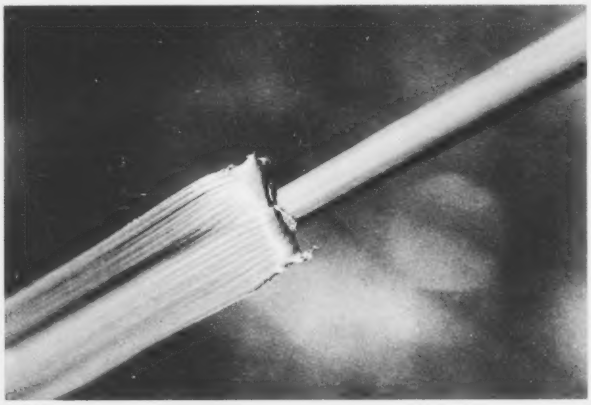
Tall fescue is closely related to meadow fescue, annual ryegrass and perennial ryegrass. Compared to meadow fescue, tall fescue is taller, has wider leaves and is deeper rooted.

There are two types of tall fescue: forage type and turf type. Turf types should not be used for forage since they may contain high levels of endophyte, which improves plant vigour, but can harm livestock.

Use in Alberta

The principal use of tall fescue has been for pasture and hay. It has not been commonly used in Alberta in the past due to lack of winter hardiness although newer varieties have improved hardiness. Pasture and hay crops should be seeded to forage types, which are free of, or have low levels of endophytes.

Turf type tall fescues are presently grown for seed production in the Peace River region of Alberta and British Columbia and in the irrigated areas of southern Alberta. Endophytes, mainly present in the turf varieties to improve plant vigour, can produce toxic compounds at levels harmful to livestock utilizing them for pasture, hay or seed by-products.



TALL FESCUE LEAF

DESCRIPTION

Tall fescue stems are erect or semi-erect, fairly stout and smooth with a maximum height over a meter. Leaves are mainly basal. Leaf sheaths are smooth, open, have overlapping margins and are often purplish at the base of the plant. Leaf blades are stiff, dark green, flat, up to 12 mm wide, hairless, have rough edges and pointed tips. The upper side is ribbed and the underside is shiny. Leaves have a short ligule, up to about 1 mm long and usually have auricles, which are up to 2 mm long and claw-like or blunt.

TALL FESCUE LEAVES ARE MAINLY BASAL

Minor vegetative differences can been used to distinguish tall fescue from meadow fescue, annual and perennial ryegrass. New leaves of tall fescue have hairs on the auricles and the margin of the collar, while meadow fescue does not. Also, the leaves tend to be wider and are not as glossy on the underside, compared to meadow fescue. Tall fescue leaves are rolled in the bud stage, while those of perennial ryegrass are folded. The edges of tall fescue leaves are rough, while those of annual ryegrass are smooth.

The root system is deep, extensive, dense, tough and coarse for a grass. Less dense stands have a bunched appearance, but tall fescue usually has short rhizomes.

The heads are panicles up to 20 cm (8 in.) or more in length with 3 to 10 cross-pollinated flowers per spikelet. The lemma may have an awn, up to 4 mm long, at the tip. Seed shatters easily.

FIGURE 22
Tall fescue plant

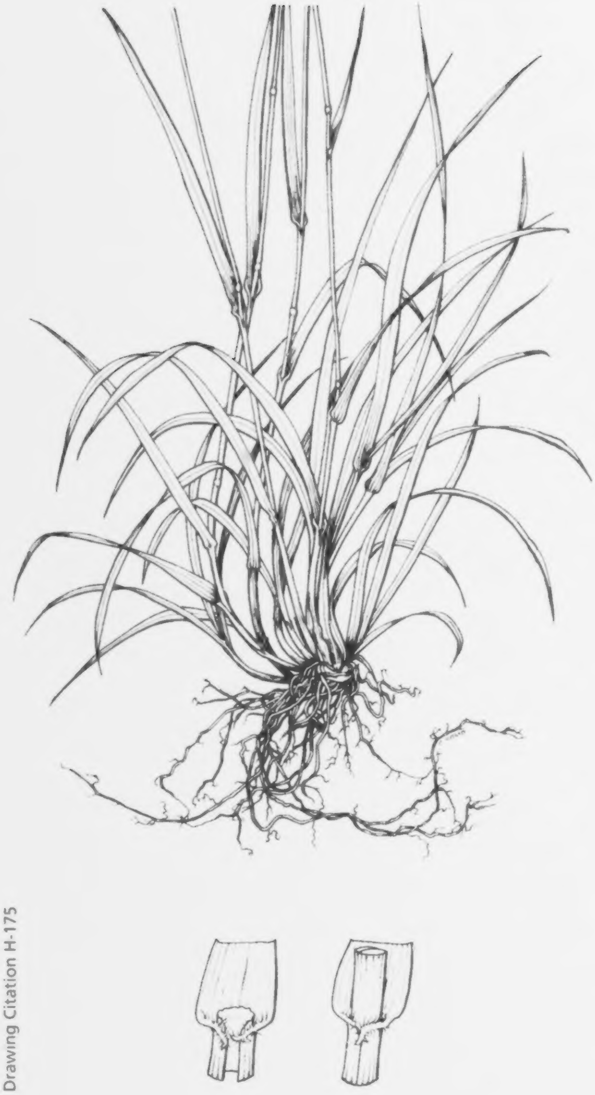


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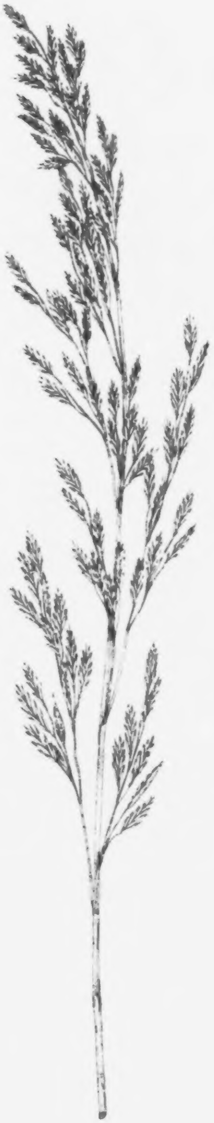
FIGURE 22 (CONTINUED)
Tall fescue head



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GROWTH AND DEVELOPMENT

Seedling vigour is good, and the crop establishes satisfactorily if conditions are favourable. Seedlings benefit from management that reduces competition from other crops and weeds.

Tall fescue initiates new shoots throughout the growing season. As hay, the main production is in the first cut with excellent regrowth for late season grazing. In pasture, the growing points remain fairly low, enabling grazed shoots to continue growing after grazing so that regrowth occurs quickly. It regrows well throughout summer and into fall. Tall fescue hardiness benefits from rest or light use during the last four to six weeks of the growing season.

Tall fescue develops a vigorous stand and becomes competitive, although it is compatible with tall growing legumes in hay stands and low growing legumes in pastures. It is long lived, although in Alberta, winter hardiness and survival have been fair. Newer varieties used in Alberta have improved winter hardiness.

YIELD AND QUALITY

Tall fescue is a high yielding forage that has a high nutritive value, which holds up well after fall frost, making it useful for fall and early winter grazing.

Endophytes

An endophyte is a fungus that lives in tall fescue plants in a symbiotic relationship without changing the appearance of the plants. The endophyte provides the plant with improved vigour, which improves its tolerance to stresses such as those caused by drought, grazing and insects. Endophytes have been bred into turf type varieties to make them more vigorous and hardy.

The endophyte can produce a harmful toxin called ergovaline (an alkaloid), which sometimes reaches levels that are harmful to animals consuming the forage. Ergovaline constricts blood flow to extremities including the feet, tail and ears. The effect is compounded by winter weather so that problems are often first apparent as frostbite in cattle during cold weather. It may appear as sensitive hind feet or lameness and progress in severe cases to hoofs and tails being sloughed off. The lameness is sometimes called fescue foot.

Threshold levels of ergovaline in the total diet that result in problems in livestock are 300 to 500 ppb (parts per billion) for horses, 400 to 750 ppb for cattle and 500 to 800 ppb for sheep, according to Aldrich-Markam (2003). Pregnant mares are very sensitive to ergovaline.

The fungus can be transmitted to tall fescue only through seed, i.e. endophyte-free seed produces plants that remain endophyte free. The percentage of seed with endophyte can be confirmed by testing, which gives an indication of the potential toxicity of pasture, hay and seed by-products (e.g. straw and seed screenings) that may be produced in the field.

Seed that has 5 per cent or fewer seeds with endophyte present is considered to be low in endophyte. Old and new varieties can be produced with seed that is free of or low in endophyte and should be purchased when establishing tall fescue hay and pasture crops.

Most seed crops are turf varieties, which can have low to high percentages of endophyte present. In the seed growing areas, levels of ergovaline above threshold levels are common in tall fescue seed screenings and have occurred in straw and fall regrowth on turf type seed fields grazed by livestock. Animal toxicities have occurred from feeding screenings and straw of some turf type varieties.

Risk of ergovaline can be reduced when utilizing high endophyte types of tall fescue. Amounts in spring leaves may be lower than fall regrowth after seed harvest. Avoiding close grazing reduces the risk since ergovaline levels are high in leaf sheaths.

Haying in the vegetative stage reduces risk since ergovaline levels are high in seed heads. Ensiling does not reduce the level of toxic compounds, but ammoniating straw does. Haying enables combining tall fescue with other feeds to dilute toxic compounds. Dilution can be accomplished in pasture by providing a portion of alternate feed. Higher levels of ergovaline have sometimes been associated with drought.

Testing is the surest way to determine feeding risks and can be done by submitting suspected feed samples to a laboratory capable of testing for ergovaline.

ADAPTATION

Tall fescue is adapted to irrigated and high precipitation regions of areas 3, 4 and 5 in Alberta (see areas in Forage Adaptation section). It is widely adapted to various soil textures but grows best on deep, moist clay or silt soils. It is adapted to organic soils. It has excellent tolerance to acidity and can be grown on soils as low as pH 4.7 but does best on slightly acidic to neutral soils. It is tolerant of alkalinity and has good tolerance to salinity. It is especially useful for pasture on irrigated saline soil.

Tall fescue has fair drought tolerance, and it recovers quickly. It has good tolerance to soils with poor internal moisture drainage, good tolerance to spring flooding and some tolerance to flooding during the growing season.

Tall fescue is more heat tolerant than most "cool season" grasses. It grows well in the cool conditions of late summer and fall.

LIMITATIONS

Hardiness is only fair and limits tall fescue use for forage in Alberta. It may survive winter in a weakened condition. There are variety differences in hardiness.

Problems associated with endophyte have limited its use in the past although endophyte-free seed will eliminate the problem.

HAY AND SILAGE

Tall fescue is productive as a hay crop and grows well with tall growing legumes, such as alfalfa and red or alsike clover. Leaves are mainly basal. The first cut of tall fescue is the most productive with regrowth being most suitable for fall or dormant season grazing. It should be harvested for hay or silage by early heading. Like most grasses, nutrient quality decreases quickly as it matures.

PASTURE

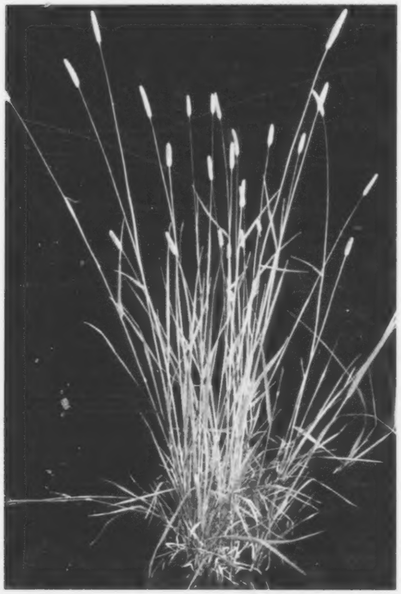
Tall fescue is most often used for pasture. It has excellent regrowth ability and does well in summer through to late fall. It has good tolerance of close and frequent grazing. When grazed fairly frequently, it produces mainly basal growth with many tillers (shoots). New tillers develop throughout the season, enabling excellent regrowth after grazing. Palatability is good in the vegetative stage. In well established stands, the sod provides good soil protection from treading.

Rotational grazing is preferred although continuous grazing is satisfactory provided stocking rates are matched to production and residual requirements. Livestock should be removed from pasture once it is grazed down to about 10 cm (4 in.) in height, leaving sufficient leafy residual to enable fast regrowth. It can be stockpiled to extend grazing into the dormant season. Leaves remain green after frost, and their stiffness improves accessibility in snow.

Creeping Foxtail

INTRODUCTION

Creeping foxtail (*Alopecurus arundinaceus* Poir.) is a long-lived moisture loving grass that is native to Europe and Asia. It is very similar to meadow foxtail (*Alopecurus pratensis L.*) in appearance, adaptation and use. The two species can be crossed. The greatest difference is that creeping foxtail has vigorous rhizomes (creeping roots) while meadow foxtail does not.



CREEPING FOXTAIL PLANT

Use in Alberta

Creeping foxtail is used to some extent in Alberta, mainly in the Gray Wooded soil zone and moist sites in the other areas. It is best used as pasture although it can be hayed or ensiled. It is noted for very early spring growth and good production throughout the season, provided there is ample moisture. It is very early maturing and becomes coarse and unpalatable when mature, making it difficult to manage and requiring an early start to grazing to keep plants vegetative. Creeping foxtail is invasive, especially in moist areas, as it spreads by rhizomes and seed.

DESCRIPTION

Stems are erect to a height of about 1 m (3 1/4 ft.).
Leaf sheaths can be smooth or hairy. The leaf blades are flat, up to 12 mm wide, smooth on the upper surface, rough on the lower surface and edges, and have pointed tips. The leaves have ligules that are 1.5 to 5 mm long, but no auricles.

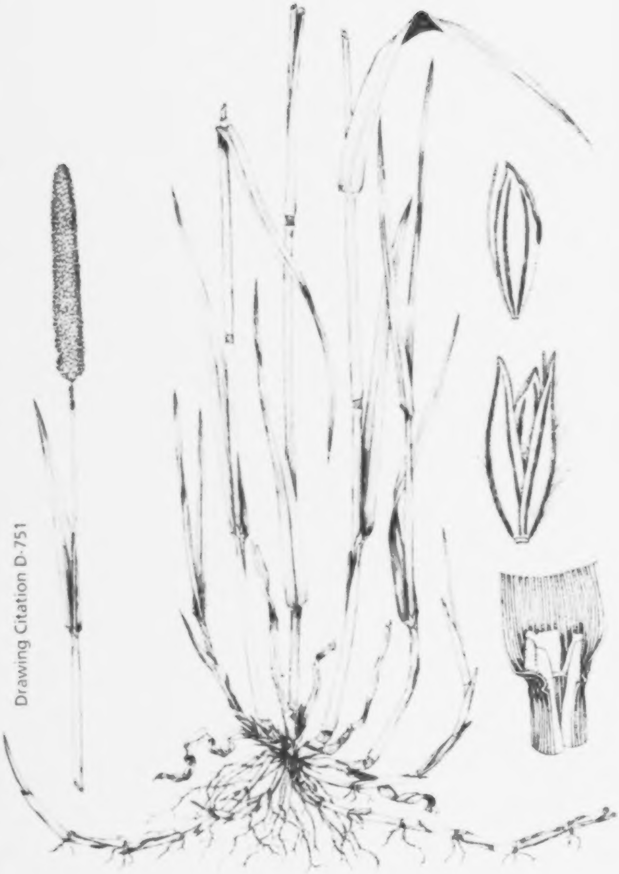
CREEPING FOXTAIL LEAF

Creeping foxtail roots are extensive with vigorous rhizomes (creeping roots), giving it the ability to spread quickly and making it invasive in moist areas. Established stands develop a firm sod.

The spike-like seed heads (compact panicles) are dense, cylindrical and soft to the touch. Heads are up to about 10 cm (4 in.) long and 1 cm (3/8 in.) or more in diameter. Heading is uneven, many shoots (tillers) do not head, and some heading will occur throughout the summer. Creeping foxtail is cross-pollinated.

Spikelets are single seeded and shatter from the head as soon as the seed is ripe. The lemma is laterally compressed and may have a short awn attached on the outside but not usually extending much beyond the end. Immature seeds are green or light brown but become black when mature and are hairy (pubescent), light and fluffy. Seeds are smaller than those of meadow foxtail.

FIGURE 23
Creeping foxtail



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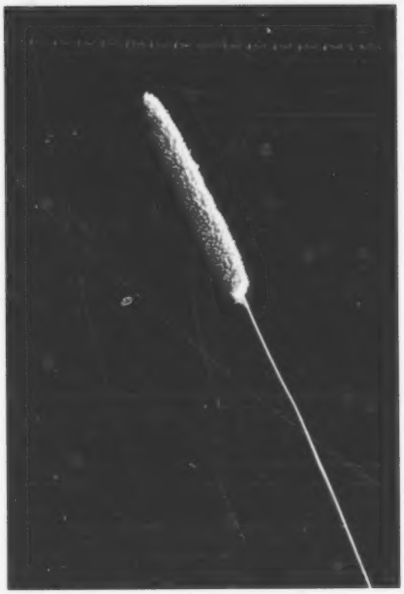
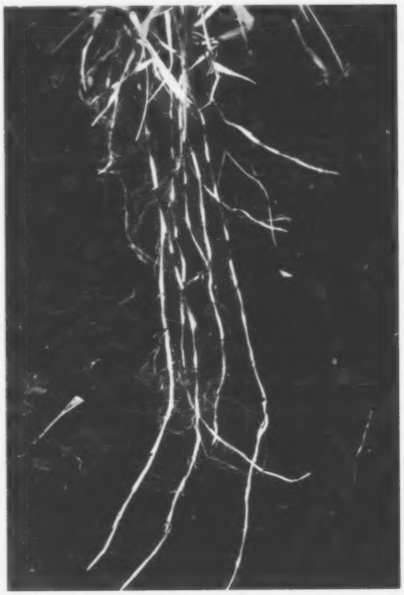
Identifying creeping versus meadow foxtail: creeping foxtail has long rhizomes, leaves are generally wider, awns usually do not extend beyond the end of the glumes and the seeds are black when mature. Meadow foxtail has little or no rhizome development, awns show beyond the end of the glumes and the seeds are grey at maturity.



CREEPING FOXTAIL SEED HEAD



CREEPING FOXTAIL RHIZOMES ARE VERY AGGRESSIVE

GROWTH AND DEVELOPMENT

The seed is difficult to plant as it bridges in seed drills, although the use of coated seed, drill boxes with agitators, etc. reduces the problem. Seedling vigour is only fair, and good establishment requires good moisture conditions and seeding without companion crops, which are very competitive with it.

Creeping foxtail is best adapted to areas where seeding may be delayed due to wet conditions. Two months should be allowed for it to establish well enough to be winter hardy. Late fall seeding for spring germination is satisfactory as the seed is tolerant of flooding. Creeping foxtail develops quickly once rhizomes begin to grow and usually establishes in the seedling year on moist sites.

Creeping foxtail tolerates cool weather and begins growth exceptionally early in spring, resulting in very early heading. Following clipping, regrowth is good, giving a good seasonal distribution of growth.

With favourable moisture conditions, established stands of creeping foxtail are aggressive, very competitive and can spread by both rhizomes and seed. Very early spring growth means it is ready to be utilized well before a legume is ready. It can be grown with aggressive legumes, but it is most often grown on very moist sites where legumes are not well adapted. Alsike clover may be a good legume companion where flooding is limited. Creeping foxtail will spread, and it can grow as an unwanted invader on moist sites.

Creeping foxtail has excellent winter hardiness and cold tolerance. It is persistent with excellent longevity.

YIELD AND QUALITY

Creeping foxtail yields are good, similar to meadow foxtail, where adapted. It is very responsive to good moisture conditions and fertilizer, especially nitrogen. It generally yields less than reed canarygrass.

The nutrient quality of creeping foxtail is good, comparable to most grasses at the same stage of maturity. As it matures very early, it is often utilized at a more mature stage, resulting in low quality feed. The initial grazing or cutting needs to be early, before the forage becomes too mature.

ADAPTATION

Creeping foxtail is adapted to the cool, moist regions of the Gray Wooded soil zone and moist regions of areas 2, 3, 4 and 5. It grows on all soil textures, but its need for moisture means that clay, silt and organic soils are generally the most suitable since they have good water-holding capacity.

Creeping foxtail has good acid tolerance and fair salinity tolerance. Creeping foxtail has poor drought tolerance, but it survives drought. It has excellent tolerance of high water tables and ponding, tolerating several weeks of flooding. It does well on flood plains and low areas where moisture is continually available. It does not tolerate permanent flooding and may only grow around the perimeter of a permanent slough.

Creeping foxtail has good tolerance of ice sheeting.

LIMITATIONS

Creeping foxtail's usefulness is limited by its creeping habit and the ability of seeds to spread with water drainage and to some extent by wind. These factors give it the ability to invade moist areas where it is not wanted.

Very early growth means it is often more mature than other forages when harvested. It is often not hayed or grazed until it is over-mature, resulting in low quality and low palatability, often being rejected by grazing livestock. Grazing close, very early in spring decreases the palatability problem.

HAY AND SILAGE

Creeping foxtail has fair suitability for hay and silage production, although its early maturity makes it difficult to manage. It can be used as dual purpose forage with the first cutting hayed and the regrowth grazed. It is very early growing and needs to be harvested early in the season, before flowering. Creeping foxtail is more resistant to lodging than meadow foxtail, and rhizomatous roots support hay harvesting equipment well. Creeping foxtail is generally grown in wet areas, which may affect harvest times, resulting in harvesting at a later maturity, which reduces the quality and palatability.

PASTURE

Creeping foxtail is well adapted to grazing, although it is difficult to manage as pasture, mainly due to very early heading. It begins growth very early in spring and regrows well to the end of the growing season, providing a long grazing season. Creeping foxtail has excellent grazing tolerance, and its strong sod resists livestock treading.

Creeping foxtail tolerates rotational or continuous grazing. Rotational grazing with small paddocks is usually necessary to force animals to graze it evenly. Stocking should begin early in the season, grazing down to about 10 cm (4 in.) in height and often enough to keep plants in the vegetative stage.

Palatability is good in the vegetative stage but very low once the forage heads out. Its very early growth results in it being more mature and low in palatability compared to less mature species. Animal performance is good as long as palatability is good.

Meadow Foxtail

INTRODUCTION

Meadow foxtail (*Alopecurus pratensis* L.) is native to temperate areas of Europe and Asia. It is found across Canada and the northern United States.

MEADOW FOXTAIL PLANTS

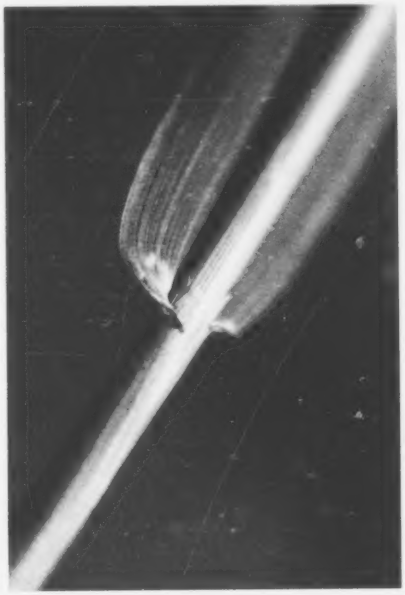
Meadow foxtail is very similar in appearance, adaptation and use to creeping foxtail (*Alopecurus arundinaceus* Poir). The two species are closely related. The greatest difference between them is that meadow foxtail does not have creeping roots while creeping foxtail has vigorous creeping roots.

Use in Alberta

Meadow foxtail is used to some extent in Alberta, mainly in the Gray Wooded soil zone, for pasture. It is best adapted to cool, moist growing conditions, especially low lying areas. It has very early growth and is high yielding with good production through to late fall. It matures exceptionally early, becomes coarse and unpalatable when mature and requires an early start to grazing or haying to keep the plants vegetative and palatable, making it difficult to manage. Seed shatters easily, and it will spread and invade into areas where it is not wanted.

DESCRIPTION

Stems grow erect to about 1 m (3 1/4 ft.) in height, but are usually shorter. Leaf sheaths are smooth and open with overlapping edges. Leaf blades are rolled in the bud stage, flat in cross section when fully expanded, fairly narrow at maturity (up to about 8 mm wide) and have pointed tips. Leaf blades are soft, hairless, with veins that give the upper surface a slightly ridged appearance and the margins (edges) are rough. Ligules are prominent, to about 2 mm long, without notches. There are no auricles.

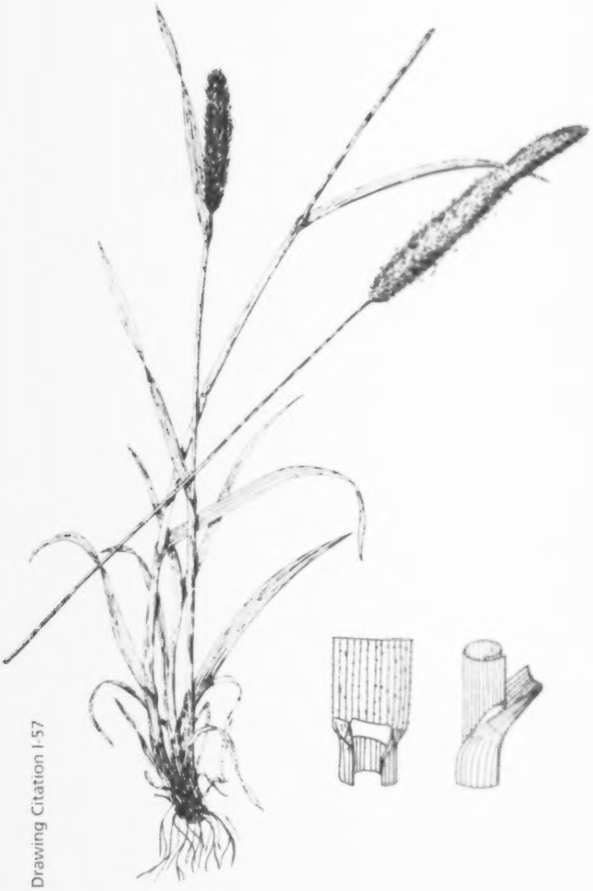


MEADOW FOXTAIL LEAF

Meadow foxtail has no rhizomes or very few short rhizomes, with limited vegetative spreading ability. Individual plants may have a bunchgrass appearance while full stands develop a firm sod when fully established.

Meadow foxtail heads are compact cylinder-shaped panicles that look like spikes, superficially similar to timothy but silky and soft to the touch due to hair and small protruding awns. The heads are up to about 10 cm (4 in.) long, up to 1 cm (3/8 in.) diameter and taper to a tip. Meadow foxtail is cross-pollinated. Spikelets have one seed and shatter as soon as the seed is ripe. Seed is laterally compressed, very light and fluffy, variable in size, up to about 4 mm long with a 5 mm bent awn attached from the outside of the lemma. Seed colour is light or medium grey.

FIGURE 24
Meadow foxtail



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Identification of meadow versus creeping foxtail: meadow foxtail has no rhizomes (or very short rhizomes), leaves are usually narrower, awns project beyond the glumes and the seed covers are grey. Creeping foxtail has long rhizomes, awns usually do not extend beyond the glumes and the seed covers are black at maturity.

GROWTH AND DEVELOPMENT

The very light, fluffy seed is difficult to plant with most drills as it easily bridges in seed boxes. Coated seed is available and makes seeding much easier as it eliminates bridging problems. As meadow foxtail is often seeded into wet areas where spring seeding is not possible, later seeding may be necessary.

MEADOW FOXTAIL SEED HEAD

Seeds germinate and emerge satisfactorily with good moisture. Two months should be allowed for it to become well enough established to survive winter. Late fall seeding for spring germination is also satisfactory since the seed tolerates spring flooding. Thin stands in moist areas often thicken up from natural re-seeding. Meadow foxtail seed may spread in flowing water to areas where it is not wanted and establish.

Meadow foxtail is tolerant of frost and begins growth exceptionally early in spring, when weather is still very cool with initial spring growth having a higher proportion of stems than most grasses. It heads out and matures exceptionally early. Regrowth ability is good through to late fall, giving it a good seasonal distribution of growth when managed as pasture. Regrowth is generally composed of a high density of small shoots.

When established, meadow foxtail is very competitive in forage mixtures, but less so than creeping foxtail. Due to its adaptation to wet sites and the need to harvest or graze it very early, it is often best grown alone. Alsike clover is a suitable companion for wet sites as long as it persists. Aggressive legumes, such as alfalfa and red clover will grow satisfactorily with meadow foxtail on well-drained sites in high precipitation areas.

Meadow foxtail has excellent winter hardiness and cold tolerance. Stands are very persistent and have excellent longevity, being more or less permanent where adapted.

Meadow Foxtail

YIELD AND QUALITY

Meadow foxtail yields well where adapted. High soil moisture levels and multiple cuttings are required for meadow foxtail to express its full yield potential.

Nutrient content of meadow foxtail is good. The rapid development of this grass often leads to use at later maturity, resulting in the harvest of low quality forage.

ADAPTATION

Meadow foxtail is adapted to wet and high precipitation sites in areas 2, 3, 4 and 5 (see Figure 1 in the Forage Adaptation chapter). It will grow on all soil textures, but because of its need for moisture to be productive, it does best on clay, silt and organic (peat) soils, which retain water well. Meadow foxtail has good tolerance of acidity, growing at pH 5.0, but it does better with more moderate conditions. It has poor tolerance to salinity.

Meadow foxtail has poor drought tolerance, becomes semi-dormant during drought and unproductive compared to more tolerant species. It resumes normal growth after drought. It is best adapted to and very productive in moist areas, especially low lying land, as it has excellent tolerance to a high water table and moisture in the root zone. It has excellent tolerance to spring flooding, including seedlings, and will withstand several weeks of flooding, but not permanent flooding. Meadow foxtail has good tolerance to ice sheeting.

LIMITATIONS

The very early spring growth and rapid onset of maturity often results in meadow foxtail being low in palatability by the time it is grazed or hayed. At these later stages, it is often rejected by livestock, and it has gained a reputation of being unpalatable. Grazing close, very early in spring decreases the problem on pastures.

Meadow foxtail use is limited as it may spread to areas where it is not wanted as the seed shatters readily, tolerates flooding and will move with flowing water. Seedlings will establish in areas with existing vegetation, including upland areas, if there is sufficient moisture.

HAY AND SILAGE

Meadow foxtail has only fair suitability for hay and silage, and its early maturity makes it difficult to manage. The first cutting does not yield as well as some grasses. It can be used as dual purpose forage with the first cut hayed early and the regrowth grazed. It has exceptionally early growth and harvesting before it heads gives the best quality, which means it needs to be cut very early in the season. Lodging can be a problem, and leaves tend to shatter during baling.

PASTURE

Meadow foxtail is well adapted to grazing although it is very difficult to manage, mainly due to very early heading. It can lengthen the grazing season as it is ready to graze very early (see Table 11) and has good regrowth, allowing for fairly frequent grazing through to the end of the growing season, provided moisture is favourable.

Meadow foxtail has excellent tolerance to grazing. Once a full stand is well established, the sod is resistant to livestock treading.

Meadow foxtail tolerates rotational or continuous grazing, although rotational grazing is the easiest to manage. With continuous grazing, it is difficult to achieve even grazing, since livestock prefer new regrowth, leaving more mature shoots to head out.

VEGETATIVE STAGE OF MEADOW FOXTAIL

Very early growth and early stem development requires that meadow foxtail pasture be grazed close in early spring, down to about 10 cm (4 in.) height and often enough to keep it vegetative. Meadow foxtail needs to be grazed with a high stocking rate, to achieve even grazing. Regrowth can be grazed approximately every four or six weeks, provided growing conditions are favourable. Pastures that head out should be hayed, to prevent seed production, since livestock grazing will not prevent all plants from setting seed.

Meadow foxtail has good palatability in the vegetative stages but not after heading. Its very early growth means it is more mature and less palatable than other species in a pasture so that it needs to be fenced separately. If kept vegetative by grazing, it will remain palatable.

In a study by Rode in 1986, meadow foxtail pasture gave lower daily steer gains than timothy at Prince George, British Columbia, leading to speculation that an anti-quality factor may have been involved.

Kentucky Bluegrass

INTRODUCTION

Kentucky bluegrass (*Poa pratensis* L.) is a widely adapted, aggressive and persistent perennial grass from Europe and Asia. It is grown in all Canadian provinces.

KENTUCKY BLUEGRASS PLANTS

Kentucky bluegrass is naturalized in North America, with local strains being adapted for survival. Forage varieties of Kentucky bluegrass have been selected for characteristics such as early growth, increased height and faster regrowth. Most varieties have been developed for turf and lawn use, with selection for many aspects including early growth, turf density, creeping ability, drought tolerance, leaf colour, disease resistance, etc. Some turf types have done well in simulated pasture trials while others have not.

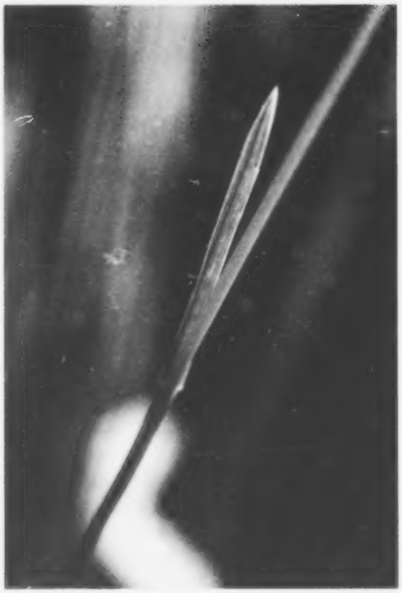
Use in Alberta

In Alberta, Kentucky bluegrass may be seeded, but it more commonly grows as a volunteer species, much the same as white clover, and both increase under close, frequent grazing. As a result, Kentucky bluegrass is the most common pasture grass in the higher rainfall areas of Alberta, especially on Gray Wooded soils and to a lesser extent on Black soils. It is also grown in irrigated areas and is commonly used for turf and reclamation. Its main limitation for agricultural use is poor productivity when moisture is limiting.

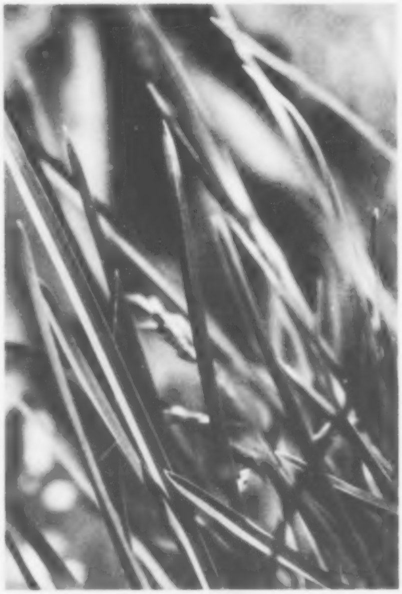
DESCRIPTION

Kentucky bluegrass has fine stems that are produced during initial spring growth and reach heights of up to 75 cm (30 in.) or more. The leaves are mainly basal, smooth, and fairly soft. The leaf sheath is slightly flattened and open with margins (edges) that may overlap. The leaf blades are folded in the bud stage, flat or v-shaped in cross section when expanded, 2 to 5 mm wide, have two parallel center veins and a boat-shaped tip. Ligules are short, about 1 to 2 mm long, and there are no auricles.

Kentucky bluegrass has shallow, fibrous roots, similar in total root mass to other common grasses but concentrated in the upper soil layers (see Table 6). Rhizomes are slender and, depending on the variety, can spread slowly to aggressively to produce a firm sod. Plants expand by tillering and by developing shoots from the rhizomes. Rhizomes are also important for carbohydrate storage, winter survival and remain dormant during drought.

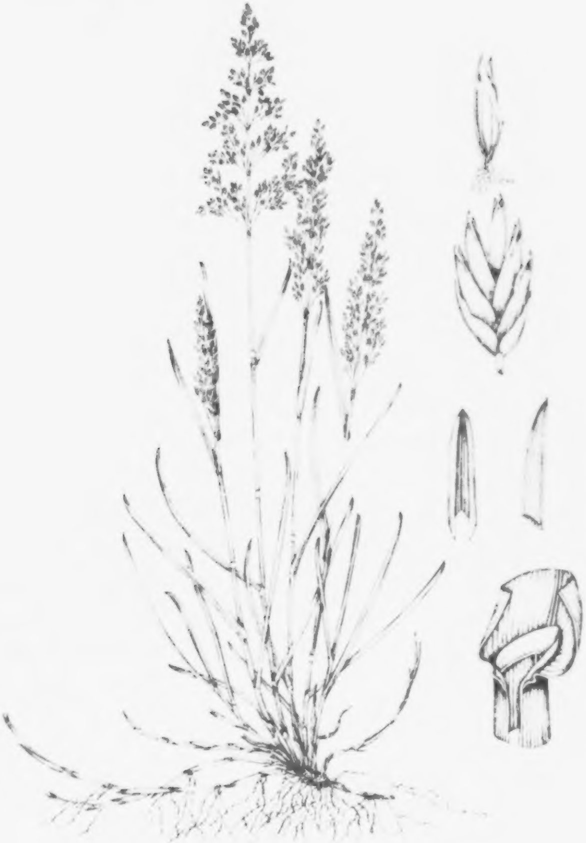


KENTUCKY BLUEGRASS LEAF



KENTUCKY BLUEGRASS LEAVES HAVE A BOAT-SHAPED TIP

FIGURE 25
Kentucky bluegrass



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KENTUCKY BLUEGRASS SEED HEAD

The seed head is a small panicle, somewhat blue, wide at the bottom, narrow at the top and 5 to 10 cm (2 - 4 in.) long. Spikelets have three to five flowers. Kentucky bluegrass most often produces seed by vegetative means, but it can also produce seed by cross pollination, i.e. it is a facultative apomict (see Glossary). Immature lemmas have cobwebby hairs at the base, which is a good distinguishing feature for this grass. The seeds are very small and require very shallow seeding (e.g. 5 mm).

GROWTH AND DEVELOPMENT

Kentucky bluegrass is very slow to germinate and establishes slowly but easily, provided it has sufficient moisture. Companion crops or tall growing forages in a mixture will slow its development. Rhizome growth does not occur until after initial establishment.

Although there are variety differences, Kentucky bluegrass is early growing in spring with the initial growth having a large proportion of heads. Shoots (tillers) are small, but thick stands develop. A large proportion of leaves and growing points remain near ground level so that regrowth following clipping is excellent regardless of the cutting stage, giving continuous but modest production to the end of the growing season. It has a very good distribution of growth in the cool, higher rainfall areas of Alberta where it is most used.

Kentucky bluegrass is low growing but very competitive and invades into most pastures, especially closely grazed pastures. It is not productive in taller growing grass or legume stands, but where adapted, it will persist in the bottom of the canopy and then flourish if the taller species diminish or are overgrazed. It is very compatible with white clover, which is also low growing, and it does well with alsike clover and birdsfoot trefoil. Old pastures in the more moist regions of Alberta are commonly made up of volunteer Kentucky bluegrass and white clover as the major forage species.

Kentucky bluegrass has excellent cold hardiness and is very persistent with excellent longevity, being more or less permanent in areas with sufficient rainfall.

YIELD AND QUALITY

Kentucky bluegrass gives modest production although total dry matter yield is greater than its low growth indicates (see Table 9). Distribution of Kentucky bluegrass yield over the season is very good.

TABLE 9
Yield of grasses with high fertility and frequent clipping 1997 – 1999

Grass	Variety	Yield kg/ha (ton/ac) Breton – Gray Wooded Soil	Lacombe – Black Soil
Kentucky Bluegrass	Troy	6,357 (2.8)	5,937 (2.7)
Orchardgrass	Kay	8,955 (4.0)	7,914 (3.5)
Meadow Bromegrass	Fleet	6,648 (3.0)	8,506 (3.8)
Creeping Red Fescue	Boreal	6,350 (2.8)	5,296 (2.4)
Reed Canarygrass	Palaton	6,097 (2.7)	5,782 (2.6)

Cutting height was approximately 7.5 cm (3 in.)

Adapted from Bjorge et al 2000 and unpublished Lacombe data

Kentucky Bluegrass

Kentucky bluegrass heads out early. Quality is equal to or better than other grasses at the same stage of maturity, with high palatability resulting in high animal intake.

ADAPTATION

Kentucky bluegrass is widely adapted, and where adapted, it is generally present. It does best in the cool, high rainfall regions of Alberta, including Black and Gray Wooded soil areas and in irrigated areas. It is most productive on fertile soils with good drainage. It does best on medium textured soil but will grow on heavy soils that are not too wet and sandy soils if they are moist. Kentucky bluegrass has good tolerance of acidity, but it prefers a pH range of about 5.5 to 7.5. It has poor tolerance to salinity.

Kentucky bluegrass has good survival under drought conditions but yields poorly even under slight moisture stress and becomes dormant under severe drought. It does best with high total rainfall, without periods of moisture deficiency. It has good tolerance to flooding, withstanding several days of flooding during the growing season and has good tolerance of excessive soil moisture in the root zone.

It needs full sunlight to be most productive but persists as a bottom grass beneath the canopy of other grasses, such as timothy.

Kentucky bluegrass is the most commonly used grass for turf in Canada, and most varieties have been developed for this purpose. Its broad adaptability, strong sod, low and dense growing habit, persistence and good appearance make it the preferred turf species. It can be mowed as often as required for good appearance provided fertility and moisture are adequate. Kentucky bluegrass is also useful for water erosion control, roadside seeding, forestry rights of way, etc. where its low maintenance requirement is an added advantage.

LIMITATIONS

The greatest limitation of Kentucky bluegrass is lack of productivity during drought. Even in regions that generally have high rainfall, a short period of moisture stress results in a yield reduction. Very closely grazed stands with low fertility become especially shallow rooted and more susceptible to drought. Once soil moisture improves, the forage resumes growth.

HAY AND SILAGE

Kentucky bluegrass is low growing and poorly suited for hay and silage production, is generally not seeded for these purposes but is commonly present as a volunteer species. Harvesting between early heading and the early flower stage is satisfactory for most purposes. Low height and basal leaf production limit the ability of machine harvesting, and the forage is more difficult to cut than most grasses. It cures well in the field, and both hay and silage are very palatable.

PASTURE

Kentucky bluegrass is an important pasture crop in Alberta, especially in permanent pastures. It is mainly a volunteer crop, increasing when other species are grazed out, but it is also seeded. Variety selection should be based on known performance.

Kentucky bluegrass has a significant proportion of leaf material and growing points below the bite level of grazing livestock. It has excellent grazing tolerance and thrives under close, frequent grazing, but is less tolerant of close grazing than volunteer white clover. Kentucky bluegrass develops a firm, dense sod and is very resistant to livestock treading.

This forage is easily managed and is suitable for and does well with either continuous or rotational grazing. If a stand is thick and healthy, it can be rotationally grazed frequently, down to about 5 cm (2 in.), closer than most grasses. It can be grazed three to four times per season in Alberta depending on fertility and moisture availability.

Kentucky bluegrass is suitable for dormant season grazing (Table 8). Summer regrowth has good quality in late fall.

Kentucky bluegrass has excellent palatability in the vegetative stage. Once it heads, palatability is low, although it is more palatable after heading than most grasses.

Orchardgrass

INTRODUCTION

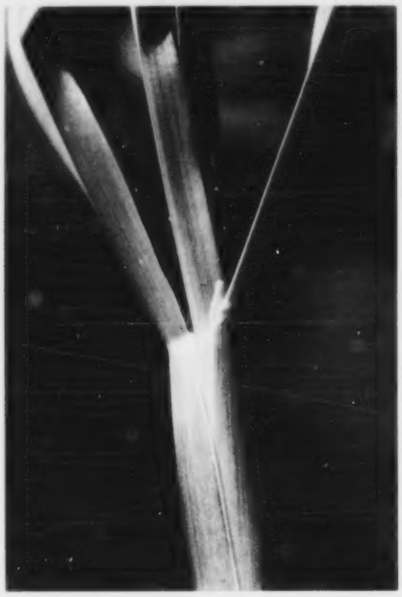
Orchardgrass (*Dactylis glomerata* L.) is native to Europe, northern Africa and Asia. Some hardy introductions used in Canada originated from Russia and other northern areas.

ORCHARDGRASS PLANTS

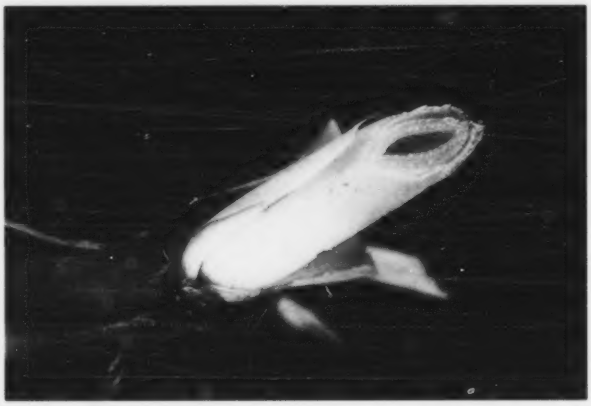
Use in Alberta
Orchardgrass is most commonly used for pasture in Alberta. It is used to some extent for hay and dual purpose hay and pasture. Its main advantage for pasture is excellent regrowth and good mid to late season yield. Hardy orchardgrass varieties are adapted to areas of the Black and Gray Wooded soil zones where winters are less severe and to the irrigated areas of southern Alberta. Orchardgrass is very palatable in its vegetative stage and is readily grazed by livestock. Its main disadvantage is that hardiness is only fair, and the most hardy varieties should be used.

DESCRIPTION

Orchardgrass is a bunch grass (i.e. it grows in tufts or clumps) with erect stems to about 1 m (3 1/4 ft.) or more in height. The lower portion of the stem and especially the leaf sheaths are flattened in cross section, which is a good identification characteristic.

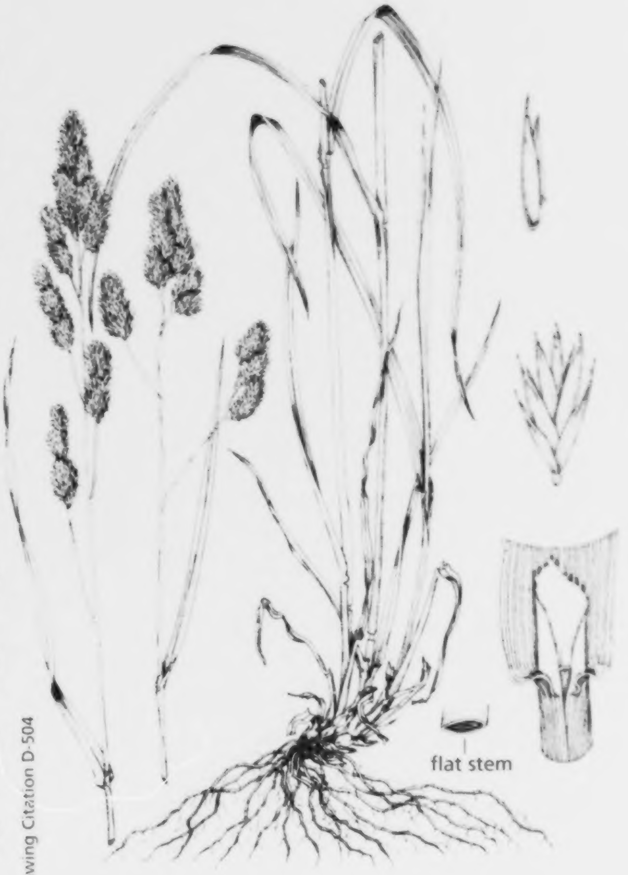


ORCHARDGRASS LEAVES



LOWER STEM AND LEAF SHEATHS ARE FLATTENED

FIGURE 26
Orchardgrass



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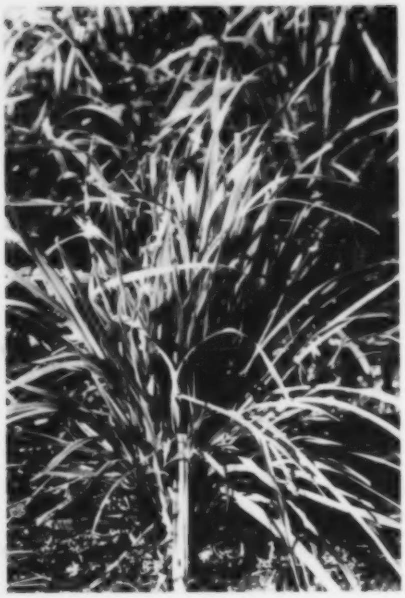


ORCHARDGRASS HAS A HIGH PROPORTION OF BASAL LEAVES

Leaves are mainly basal, with smooth sheaths that are open with overlapping edges at the top. Leaves are folded in the bud stage and V-shaped to flat when fully expanded. Young leaves have boat-shaped tips; older leaves taper to a sharp point. Leaves are soft, hairless, up to 1 cm (3/8 in.) or more in width, long, and light green or blue-green. There are no auricles, but there is a large ligule, up to about 8 mm in length.

Orchardgrass has an extensive fibrous root system (Table 6). Roots are dense but not as deep as bromegrass or the wheatgrasses. Orchardgrass has a distinct bunch growth habit, with no rhizomes, and does not form a continuous sod, leaving some bare areas between plants. Plant bases become larger over time, due to the production of new shoots (tillers) around the perimeter of the crowns.

The orchardgrass seed head is a panicle up to 20 cm (8 in.) long, with spikelets in clusters on one side of stiff panicle branches. Spikelets usually have three or four flowers, which are cross-pollinated. Seeds are small (6 - 7 mm long), may have awn tips on the lemma and are chaffy and light, making them difficult to handle with some drills. Orchardgrass seeds are not as long lived during storage as most other grasses.

ORCHARDGRASS SEED HEAD

GROWTH AND DEVELOPMENT

Seedlings are vigorous, quick establishing, shade tolerant and compete well with a nurse crop. Full yield potential is normally reached the year following seeding. Seedlings often establish from seed that sets in existing stands.

Orchardgrass does not start growth as early in spring as many tame grasses in Alberta but develops quickly when soil temperatures increase (Table 11). Heading occurs in the initial spring growth, but there is a high percentage of shoots that do not head. New shoots continually grow from the base of the plant providing excellent regrowth rate of leafy shoots, making orchardgrass flexible in the time of cutting or grazing. It is productive during summer and has good late fall productivity, making for a good distribution of growth, provided moisture is adequate. It is responsive to good fertility, especially nitrogen.

In spring at Lacombe, orchardgrass reached a yield of 1,400 lb/a some 7 days later than meadow bromegrass and 10 days later than smooth bromegrass. After close cutting in late July, it reached 1,400 lb/a 2 days later than meadow bromegrass and 7 days before smooth bromegrass (see Table 3).

Stem bases are important for carbohydrate storage during the growing season, providing energy for regrowth. Orchardgrass plants accumulate carbohydrates for winter survival.

Orchardgrass is a very aggressive grass and competes strongly with other species in a mixture. Aggressive legumes, such as alfalfa, are compatible with it. Despite orchardgrass having a very open stand, invaders have difficulty establishing into it.

Winter hardiness is fair to good, limiting the adaptation of orchardgrass to areas with favourable winter conditions. Longevity is fair to good, depending on variety. May-seeded Kay orchardgrass crowns tolerated -23° C compared to Regar meadow bromegrass at -23° C, Carlton smooth bromegrass at -28° C and Fairway crested wheatgrass at -32° C (see Table 10).

Orchardgrass may survive winter with only one or two living shoots on a plant, giving it a very slow start in spring. Snow cover is important in insulating crowns from low winter temperatures. This condition can be accomplished by leaving some residue standing in the field over winter to trap snow. The hardiest varieties are the most persistent in Alberta.

YIELD AND QUALITY

Orchardgrass has good yield with somewhat less production on the first cut and more on the second cut of hay than for most other grasses. Its rapid regrowth ability enables it to contribute well in second-cut hay. In pasture, with three or four clippings per year, orchardgrass can be very productive (see Table 9).

Orchardgrass does well with high fertility and often out-yields other grasses in high precipitation areas, but does less well under somewhat drier conditions (see Table 9 and Table 11).

Orchardgrass quality is similar to other grasses grown in Alberta. Since it develops and matures very quickly, fiber will also increase quickly, making it advantageous to harvest it early.

Orchardgrass

ADAPTATION

Orchardgrass is adapted to the high precipitation areas of Alberta including Gray Wooded soils and higher rainfall areas of the Black soils where winter soil temperatures are moderate. It does well under irrigation. The hardiest varieties are the most adapted.

It is best adapted to medium textured soils but also does well on other soil textures if moisture conditions are favourable. It has fair tolerance to acidity, growing well at pH down to about 5.5. It has only fair tolerance to salinity and does not do well on high pH (alkaline) soils.

Orchardgrass has fair drought tolerance, less than bromegrasses, but resumes growth very quickly once a dry period ends. It is best adapted to soils with good internal moisture drainage and high annual rainfall. It has fair tolerance to spring flooding and excess moisture in the root zone, but poor tolerance to flooding during the growing season.

Orchardgrass is quite heat tolerant and has some shade tolerance.

LIMITATIONS

Moderate winter hardiness is the main limitation to orchardgrass production in Alberta, even when the hardiest varieties are used. It is common for orchardgrass to survive winter but to do so in a weakened condition. Sometimes much of the plant winterkills, leaving only a few small shoots to begin spring growth, which is then initiated very slowly. King (1994) found that leaving enough standing residue in the fall to hold snow helps protect the crowns from extremely cold temperatures, which may cause winterkill.

HAY AND SILAGE

Orchardgrass has good suitability for hay and silage production. It matures earlier than single cut red clover or other late maturing legumes. Orchardgrass produces well in first and second cuttings.

Orchardgrass should be harvested in the early heading stage, as quality is reduced once the forage has headed. It is effective in dual purpose hay and pasture systems, with the first cut hayed and the regrowth grazed in late summer or fall.

Lodging can be a problem, especially in pure orchardgrass stands on heavily fertilized fields. It is slow to dry as the swaths are compact and do not allow for much air circulation. If baling is delayed, the fast regrowth of the orchardgrass may cause it to grow through the swaths.

PASTURE

Orchardgrass is most commonly used for pasture in Alberta and is well suited for this purpose. It does not start growth early, but peaks in production by late spring and then produces well for the remainder of the season provided soil moisture and fertility are adequate.

Orchardgrass has excellent tolerance to grazing, provided it is not grazed too close. Continuous, close grazing is harmful to the stand. Orchardgrass does not form a firm sod, and it has soft lush growth, resulting in treading and trampling damage, especially if the pasture is soft or wet.

The forage is most productive with rotational grazing where grazing height is controlled. It should be grazed in the vegetative stage, leaving enough leaf material in the residue for efficient photosynthesis. It can be grazed down to about 10 cm (4 in.) height. Under good fertility and good growing conditions, it can be grazed after about four to six weeks of regrowth in June and July. If lower leaves begin to die and brown off in the canopy, it should be grazed.

Orchardgrass can be grazed continuously, but care should be taken to match stocking rate with production so that it is grazed lightly and not too closely. Continuous grazing of mixtures is likely to result in preferential grazing of orchardgrass, resulting in it being overgrazed and leaving less palatable plants ungrazed.

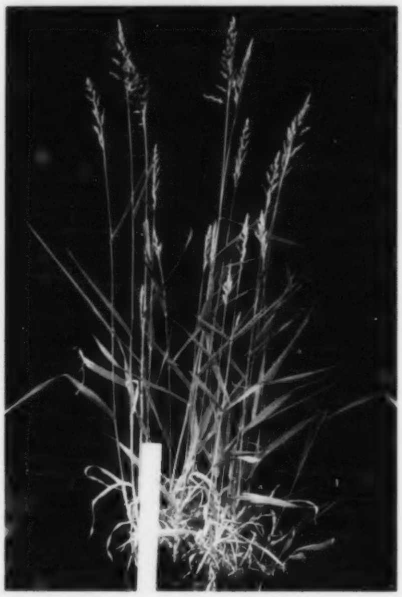
Orchardgrass regrows well and can be stockpiled for late fall grazing (Table 8). Rest or light grazing in late summer and early fall increases the plants' ability to build up energy reserves. Enough residual should remain after fall grazing to hold snow.

It has excellent palatability in the vegetative stage, but it becomes low in palatability after heading. Livestock will selectively graze the vegetative shoots and graze them very closely before selecting other species. Paddocks with orchardgrass or orchardgrass mixtures should be fenced separately to prevent livestock from preferentially grazing it. Livestock do well on it.

Reed Canarygrass

INTRODUCTION

Reed canarygrass (*Phalaris arundinacea* L.) is native to North America, Europe and Asia. Varieties used in Canada are of European and North American origin. For example, the Frontier variety was developed from native North American collections.



REED CANARYGRASS PLANT

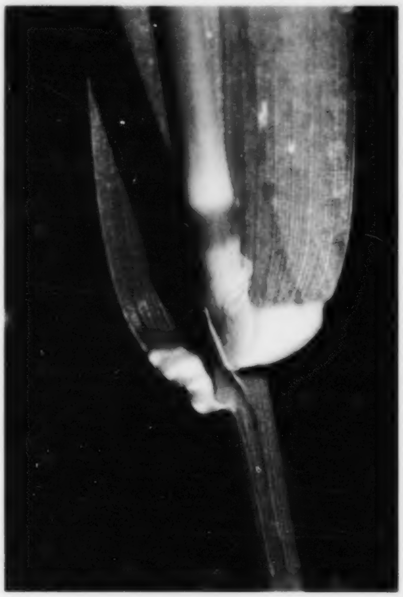
Newer varieties of reed canarygrass have reduced levels of alkaloids. These varieties reduce or eliminate palatability and livestock digestive problems that are associated with alkaloids in the older varieties. Old or new stands established with old varieties or the use of common seed can result in stands with the potential for high alkaloid levels.

Use in Alberta

Reed canarygrass is a long-lived perennial grass that is well adapted and commonly grown on moist and wet areas throughout Alberta. It is also adapted to dryland in the Gray Wooded and Black soil zones. Reed canarygrass is used mainly for hay but is also very suitable for pasture and controlling water erosion. It grows well along waterways, but it restricts water flow, making it undesirable in irrigation ditches. Timely harvesting and the use of low alkaloid varieties eliminate most of the quality problems.

DESCRIPTION

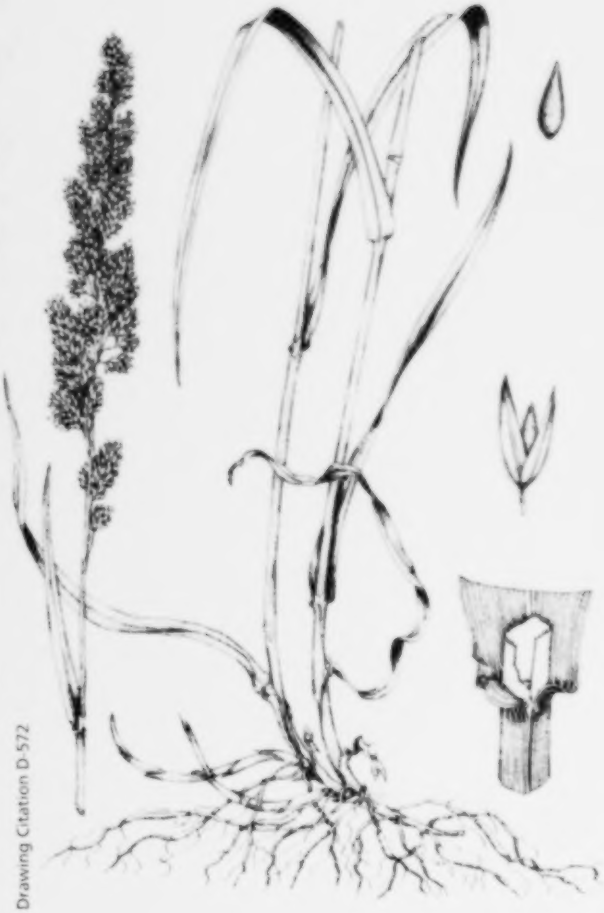
Stems are leafy, coarse, erect and up to 2 m (6 1/2 ft.) or more in height when headed. Leaf sheaths are smooth and split (open) with overlapping margins. Leaf blades are flat, widest of the tame grasses (to 20 mm), long and taper to a sharp point. They are pale green, have fine veins on the upper surface, prominent midrib on the underside and are hairless except for slightly rough edges (margins). Ligules are long, up to 7 mm or more in length, but there are no auricles.



REED CANARYGRASS LEAF

Reed canarygrass has an extensive, deep root system. The crown is below the soil surface, giving it some protection from cold. Rhizomes are large in diameter, pinkish with obvious scales, but since they are short, the plants often have a bunched appearance. Rhizomes branch but creep slowly, developing a dense, strong sod by the third year if the stand is well established. Rhizomes are important for carbohydrate storage, and new shoots and roots develop from them.

FIGURE 27
Reed canarygrass



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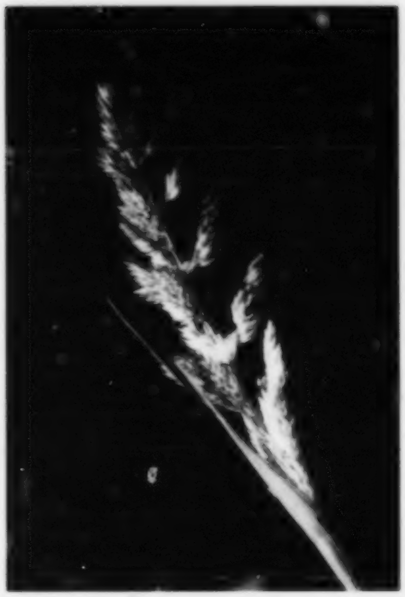
The head (inflorescence) of reed canarygrass is a lobed panicle, up to about 20 cm (8 in.) long, spread open only during flowering and otherwise contracted. The spikelets are crowded on one side of the panicle branches and produce only one fertile flower, which is cross-pollinated. Seeds are small (4 mm long), slightly flattened, smooth, shiny and vary in colour from light grey to dark brown, with some yellow seeds occurring in some varieties. Seed shatters easily from the heads when ripe, and germination decreases more quickly than most other species during storage.



REED CANARYGRASS SEED HEAD

REED CANARYGRASS SEED HEADS IN FIELD

GROWTH AND DEVELOPMENT

Reed canarygrass seeds germinate slowly, and seedlings develop slowly, benefiting from reduced competition from other crops and weeds. Early spring seeding without a companion crop is best. Midsummer planting is usually satisfactory although these stands often do not reach full productivity the following year. Reed canarygrass seeds and seedlings can withstand a few weeks of flooding, but not prolonged flooding. Sod develops slowly and new stands should not be grazed until they are completely established to avoid creating a rough pasture.

Spring growth is early and vigorous with leafy stems and seed heads developing on the first growth. Growing points are elevated on shoots that have stems, whether they develop seed heads or not and whether it is initial growth or regrowth. After harvesting or grazing, regrowth is from existing shoots with intact growing points and/or new tillers (shoots) and rhizome buds. Reed canarygrass has good regrowth ability, giving a good distribution of yield. It needs sufficient leaves to build up carbohydrate levels in late summer and early fall for vigorous growth the following spring.

Once established, reed canarygrass is aggressive, very tall growing and very competitive to other forages. It is not especially suitable for use in mixtures since it is most often grown in wet areas, where few other tame forages will grow. Where it is not too wet, mixtures with legumes, such as alsike clover and alfalfa can be used. In pasture mixtures, the reduced height decreases the shading effect, but livestock may selectively avoid reed canarygrass.

Short durations between grazing favours other forages that have rapid regrowth while longer durations help to keep reed canarygrass vigorous. With close grazing, aggressive plants with low growing points, such as bluegrass, will invade.

Reed canarygrass has excellent persistence and longevity. It is less hardy than some grasses (Table 10). Winterkill is not common but can occur if there is a lack of snow cover and cold winter weather.

YIELD AND QUALITY

Reed canarygrass is very high yielding on wet soils while on upland sites it yields more or less comparably to other high yielding grasses.

Quality in the vegetative stage is good for a grass, due to high leaf content. A large amount of stem material is produced by the time the first growth heads out. Stems become coarse and fibrous as they mature so that quality and palatability decrease quickly with advancing maturity.

Reed canarygrass has a reputation for having low quality. This concern is partly due to its production in low lying areas where there are few legumes and other forbs that would increase the feed quality of a mixture. Harvest in low lying areas is often late to allow the areas to dry up, resulting in more mature plants with reduced quality.

Older varieties of reed canarygrass have the potential to have high levels of alkaloids, which reduce palatability and daily intake by livestock. The older varieties may cause digestive problems, including diarrhea, resulting in unthrifty livestock and reduced weight gains. Sheep are more affected than cattle.

High alkaloid reed canarygrass is most likely to be found in older stands that were established before low alkaloid varieties were available, but the high alkaloids may occur with newer stands if they are seeded with older varieties. High alkaloid reed canarygrass may or may not develop toxic amounts of alkaloids. The highest levels of alkaloids accumulate in leaves and are most likely to occur in the regrowth, under drought stress and when high amounts of nitrogen fertilizer is used. Haying reduces the levels of alkaloids.

Reed canarygrass varieties developed in recent years have reduced alkaloid levels, which avoids most or all of the problems associated with them. Because many alkaloids can be present in reed canarygrass, varieties vary from having a reduced number of alkaloids to being more or less free of alkaloids.

ADAPTATION

Reed canarygrass is adapted to wet sites across Alberta, and to upland sites in the Gray Wooded and Black soil regions. It does best on clay and silt but is adapted to a wide range of soil textures, including peat, provided moisture conditions are suitable. Reed canarygrass has excellent acidity tolerance, withstanding pH levels of 4.9 to 8.3, but it grows best with less extreme soil conditions. It has good salt tolerance.

Reed canarygrass has good drought tolerance and is adapted to upland sites with good moisture-holding capacity. Roots of mature plants tolerate poor soil aeration, giving it excellent tolerance to excess soil moisture and enabling it to live for several weeks of shallow flooding. It is best adapted to wet areas where land floods in spring and the water table is near the surface at other times. It grows well on lowland that is flooded intermittently, around permanent sloughs and lakes and along streams.

It grows well under cool conditions and is also heat tolerant. It has good tolerance to ice sheeting.

Reed Canarygrass

Reed canarygrass is useful for conservation purposes since the rhizomes hold soil well, and it is adapted to both wet and dry areas. It is useful for controlling water erosion on temporary watercourses and along stream banks. Its tall growth is a disadvantage and it is undesirable along irrigation ditches where it slows water flow and causes silt deposits to form.

LIMITATIONS

The main limitation to the use of reed canarygrass is that it is thought of as being unpalatable and low in quality. Reed canarygrass is usually grown on wet sites, which have no legumes to increase the quality. In wet locations, haying often occurs after heading, when quality is lower. This situation can be corrected by harvesting earlier if the soil is dry enough.

On pasture, livestock avoid grazing the wettest areas where reed canarygrass grows and often find it less palatable than other species by the time they do graze it. This problem can be corrected by fencing reed canarygrass separately and grazing it in less mature stages, when its palatability is good. The concerns of anti-quality due to alkaloids are minimal with low alkaloid varieties.

HAY AND SILAGE

Reed canarygrass is well suited to a two-cut hay system. The second cutting yields much less than the first cutting and is often grazed.

Total energy and protein yields peak at the heading stage, decline slightly by flowering and then drop quickly. Reed canarygrass regrows satisfactorily whether it is cut early for best quality or is left until later maturity. To harvest a significant acreage of good quality hay, cutting from the boot stage to heading allows time for good regrowth. The earliest cut fields will have more time for regrowth, which will compensate for somewhat lower first cut yields. Legume mixtures should be hayed when it is best for the legume to be cut.

Harvesting reed canarygrass is more difficult than most forage due to its tough, tall stems. It usually stands up well although lodging can be a problem.

Alkaloids are decreased but not eliminated during hay curing. Alkaloid feeding problems can be avoided by dilution with other feed.

PASTURE

Reed canarygrass begins growth early in spring, has a high yield and regrows well, making it suitable for pasture production. It has good tolerance to light grazing, but the stand is weakened by close grazing, which results in slow regrowth. Established stands develop a strong sod that resists animal treading.

Initial spring growth is rapid and is easiest to manage if it is rotationally grazed to achieve even grazing and prevent heading. Continuous, light grazing is satisfactory although it is difficult to achieve even grazing.

Reed canarygrass should be grazed before stem elongation. It should not be grazed closer than 10 cm (4 in.), leaving a good cover of leafy residue. It will produce two or three high yielding grazings per season. Reed canarygrass leaves have poor frost tolerance, making it less suitable than most grasses for dormant season grazing.

REED CANARYGRASS IS FAIRLY PALATABLE IN THE VEGETATIVE STATE

Reed canarygrass is fairly palatable in the vegetative stage and gives good animal performance, provided alkaloids are not a factor. It is likely to be less palatable than other grasses, such as timothy, in a mixture. Once headed, palatability is very low due to the coarse stemmy growth and low quality.

If alkaloid levels are high, palatability is lower, and digestive problems may occur.

Italian Ryegrass

INTRODUCTION

Italian ryegrass (*Lolium perenne* L. ssp. *multiflorum* (Lam.) Husnot.) originates in Europe where it is grown as an annual or short-lived perennial. It is grown as an annual in Alberta, as it does not generally survive winter, and is often called annual ryegrass. It is very leafy and is best used as pasture, although some varieties may set seed. If it does persist over winter, it will set seed the following spring.

ITALIAN RYEGRASS PLANT

Westerwold ryegrass is a type of Italian ryegrass from the Netherlands, which is more upright growing, taller, develops stems and normally sets seed in the establishment year, making it most useful for silage or hay. It is the least likely of the Italian ryegrasses to survive winter in Alberta.

There are diploid and tetraploid varieties of Italian and Westerwold types. Tetraploids have wider leaves, develop fewer shoots (tillers) and have larger seed than diploids.

Italian ryegrass is similar in appearance to and will cross with perennial ryegrass. Italian ryegrass leaves are rolled in the leaf emergence stage, lemmas usually have awns and there are a high number of seeds in each spikelet. Perennial ryegrass has folded leaves in the leaf-emerging stage, fewer seeds per spikelet and usually has no awns. Italian ryegrass plants are larger and taller. Identification is difficult as there are many intermediates between Italian and perennial ryegrass.

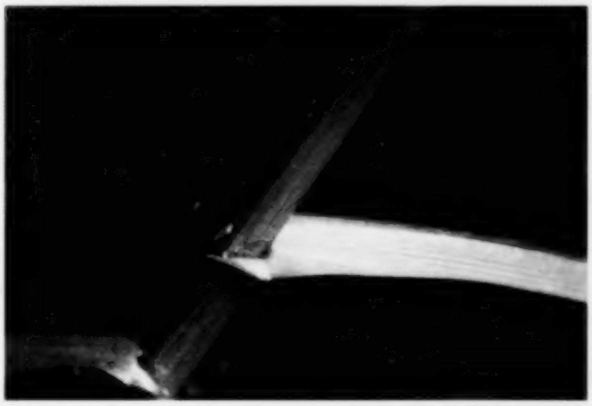
Italian ryegrass is also similar to meadow and tall fescue and can be crossed with them. These crosses are called *festuloliums*. Italian ryegrass leaf margins are smooth at the base while those of meadow fescue are rough. Italian ryegrass has narrower auricles and longer ligules (1 - 2 mm) than tall or meadow fescue (less than 1 mm).

Use in Alberta

Italian ryegrass is grown in Alberta, mainly as annual pasture for mid to late season grazing or under-seeding with cereal silage crops to provide fall grazing. It can be used for silage or hay, especially the Westerwold types. Its main limitation is moisture, and it should be grown in the higher rainfall areas of the Gray Wooded and Black soil zones or with irrigation. Italian ryegrass is also used for environmental purposes as it provides fast ground cover.

DESCRIPTION

Vegetative growth of Italian ryegrass is upright initially, but it tends to lodge, with a vegetative stand height of up to 40 cm (16 in.). The Westerwold types are taller. Leaf sheaths are reddish at the base, open, have overlapping margins and are hairless. Leaf blades are rolled in the leaf-emerging stage and are flat when emerged. Leaf blades are slightly keeled, dark green, up to about 10 mm wide, long, hairless and taper to a point. The upper leaf surface is ridged and not glossy, the underside is glossy and the edges are smooth at the base. Auricles are variable, from long and claw-like to short and blunt, and the ligule is up to 2 mm or more in length.



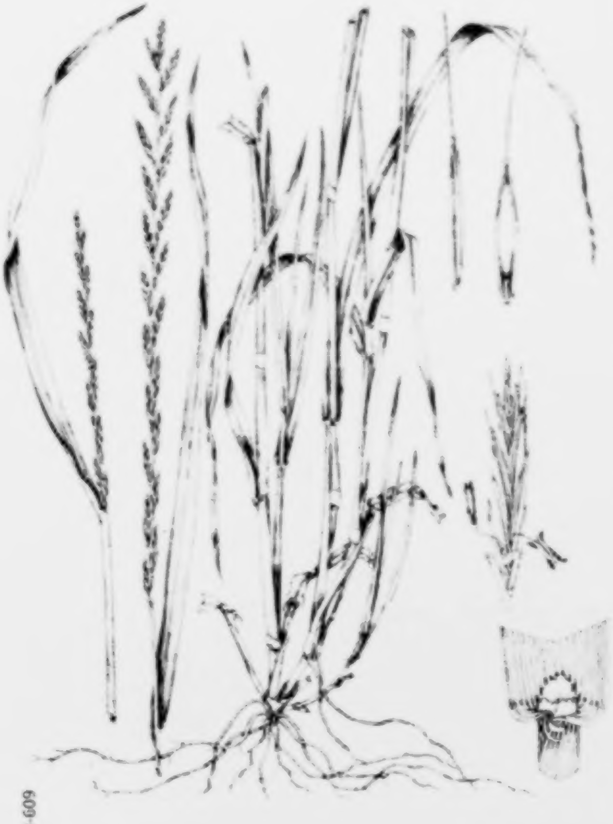
ITALIAN RYEGRASS LEAF

Italian Ryegrass

Italian ryegrass roots are shallow, fibrous and very dense with a large total mass. It has a bunch growth habit, but roots can develop from the base of the shoots and from vegetative stems.

Stems are up to about 1 m (3 1/4 ft.) in height. Seed heads (spikes) are up to 25 cm (10 in.) or more in length with spikelets attached alternately and edgewise to the rachis (stem). Italian ryegrass spikelets have 10 to 20 flowers, which are cross-pollinated. Lemmas on the upper portion of the spikelets have short awns. Seeds shatter easily.

FIGURE 28
Italian ryegrass



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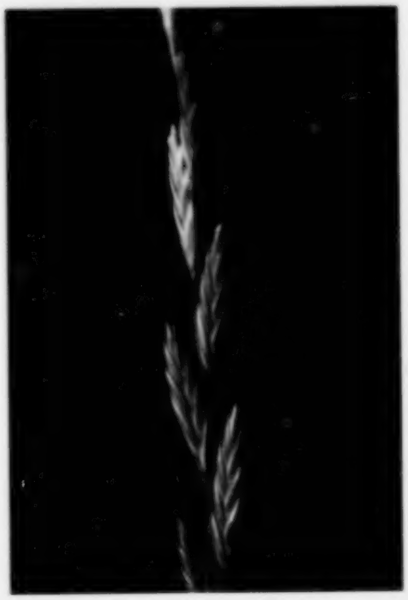


ITALIAN RYEGRASS SEED HEAD

GROWTH AND DEVELOPMENT

Italian ryegrass seeds germinate quickly. Seedlings have high vigour, are competitive and establish very easily and quickly compared to most forages, although not as quickly as annual cereals. It establishes more quickly than perennial ryegrass and can be grazed in about eight weeks after seeding if growing conditions are excellent. It is not competitive enough to do well in the same row with cereals and benefits from good weed control during establishment. Heavier seeding rates can be used to attain more production early in the season.

Italian ryegrass remains mainly vegetative in its seeding year with spring-seeded stands being well established and productive by midsummer. The growing points are near ground level in vegetative shoots, and plants develop many tillers (shoots) throughout the growing season so that regrowth ability is excellent. It is productive during cool weather, including late fall, until killing frost. Westerwold types grow as annuals, develop stems, head out and produce seed in the seeding year. They regrow well and can be harvested or grazed again.

Once it is established, Italian ryegrass is very competitive with other species, especially if nitrogen levels are high. It can be seeded alone for summer and fall grazing or in mixtures. It can also be double cropped with cereal silage or grain crops, with the Italian ryegrass re-growing for late fall or early winter pasture. If used in a mixture with perennial forages, it should be seeded at a low rate as it is very competitive to the slower establishing perennials.

Italian ryegrass has poor winter hardiness but will occasionally survive winter in Alberta.

YIELD AND QUALITY

Italian ryegrass productivity is very good, provided fertility and moisture are favourable. It is noted for its high quality, and the leaves are very soft and palatable. Digestibility is high in the vegetative stage of the plant.

ADAPTATION

Italian ryegrass is adapted to the higher rainfall areas of the Gray and Black soil zones and irrigated areas. It grows best on fertile, well-drained soil. It is adapted to a wide range of soil types although sandy soils are likely to be limited in moisture. Italian ryegrass has good acid tolerance and fair salt tolerance.

Italian ryegrass has poor drought tolerance but good tolerance to excess moisture in the root zone and will grow on soils too moist for cereal crops. It has fair tolerance to flooding during the growing season, although it will not withstand long-term flooding.

LIMITATIONS

The greatest limitation to Italian ryegrass production in Alberta is its lack of winter hardiness, which limits its use to an annual. It is intolerant of drought, goes dormant and will die out during extended periods of drought.

Westerwold types set seed readily and are potentially a competitive weed in annual crops when used in a rotation. Volunteer ryegrass is of less concern on land used for perennial forage. If ryegrass begins to develop reproductive stems, it should be grazed closely and may need to be clipped, to prevent seed formation. Ensiling or haying is the best method to prevent seed from setting once stands have headed.

HAY AND SILAGE

Italian ryegrass suitability for hay and silage is fair to good, depending on type. The more upright, taller growth and heading of Westerwold types make them easier to hay.

Westerwold types should be harvested at the late boot stage or just after heading. Italian ryegrass types can be hayed when they reach their full vegetative height or at heading. A cutting height of 7 to 8 cm (3 in.) is satisfactory.

Ryegrass stands are very high in moisture content and are slow to dry for hay. Leaf losses tend to be high compared to most grasses.

PASTURE

Italian ryegrass is most often used as annual pasture in Alberta since it remains mainly vegetative, except for the Westerwold types.

Italian ryegrass has excellent tolerance to close and frequent grazing, and it regrows quickly following grazing. The roots provide poor tolerance to treading in newly established stands but good tolerance when well developed. The vegetation is soft and leafy and easily damaged from trampling.

Italian ryegrass is best suited to rotational grazing, although continuous grazing is satisfactory. Strip grazing reduces trampling and manuring losses. After grazing, about 5 to 7 cm (2 - 3 in.) of leafy residue should be left to enable fast regrowth to occur.

It is advantageous to graze Italian ryegrass during the six week period before fall frost, as perennial forages benefit from rest at this time. Italian ryegrass has a low dormancy in the fall, grows well and remains green until a killing frost. It can be grazed in late fall and early winter, until snow is too deep for grazing.

ITALIAN RYEGRASS PASTURE

Perennial Ryegrass

INTRODUCTION

Perennial ryegrass (*Lolium perenne* L.) is a bunchgrass that originates from Europe. It is a very important pasture grass in Europe, the United States and other areas that have moist, cool summers with mild winters. It is commonly used in eastern Canada and southern British Columbia.

PERENNIAL RYEGRASS PLANT

Most varieties of perennial ryegrass developed in the United States are turf types although there are forage types. Turf types are low growing and low yielding and should be avoided for forage use.

Perennial ryegrass varieties can be diploids or tetraploids. Diploid types have higher shoot (tiller) density and are generally more persistent. Tetraploid types are more robust, have wider leaves, fewer shoots and greater drought tolerance.

Perennial and Italian ryegrass are very closely related and similar in appearance. Perennial ryegrass is different from annual ryegrass in having leaves folded (rather than rolled) in the leaf-emerging stage, 3 to 10 flowers on each spikelet and usually lacks awns. Perennial ryegrass plants are smaller than those of annual ryegrass.

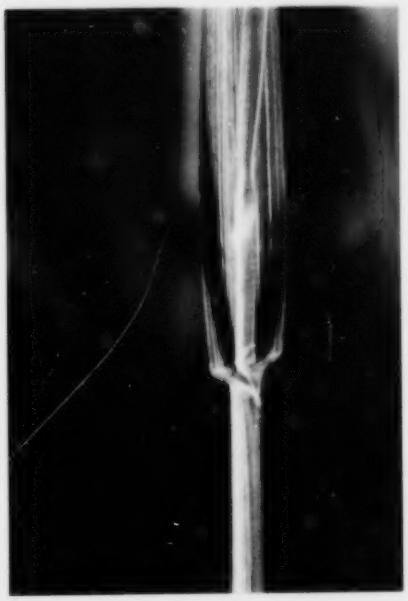
Perennial ryegrass is also very similar to tall and meadow fescue and can be crossed with them. They can be distinguished in the vegetative stages with perennial ryegrass having folded leaves in this stage, while tall and meadow fescue have rolled leaves in the leaf-emergence stage. Crosses between ryegrasses and fescues (i.e. *Festuloliums*) have improved winter hardiness compared to the ryegrasses.

Use in Alberta

Perennial ryegrass is a short-lived perennial bunchgrass that is sometimes used in Alberta as an annual. It is limited by lack of winter hardiness and drought tolerance but may survive winter under favourable conditions in the irrigated and higher precipitation areas of the Black and Gray Wooded soils. It has been mainly used for short-term pasture and conservation purposes. It is very nutritious and palatable and is suitable as a high production annual pasture.

DESCRIPTION

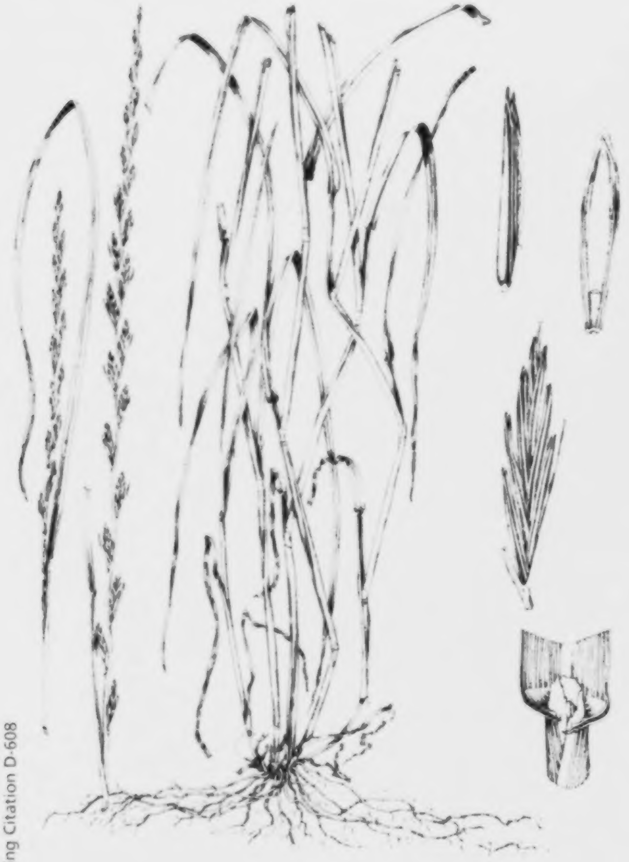
Perennial ryegrass stems are up to about 60 cm (2 ft.) high and extend above the dense, lower growing foliage, which is about 20 cm (8 in.) high. Plants have dense shoot production with soft basal leaves. Leaf sheaths are hairless with overlapping margins. Sheaths at the bottom of the shoots are reddish at the base. Leaf blades are folded when emerging and flat when expanded. They are dark green, narrow (up to about 6 mm wide), hairless, keeled and taper to a point. Veins show on the upper surface of the leaf while the lower surface is smooth and glossy. Auricles are small and claw-like, and ligules are short, up to about 2 mm long.



PERENNIAL RYEGRASS LEAF

Perennial ryegrass has a fibrous root system that is dense, but quite shallow, providing it less drought tolerance than most perennial grasses. It has a bunch habit of growth.

FIGURE 29
Perennial ryegrass



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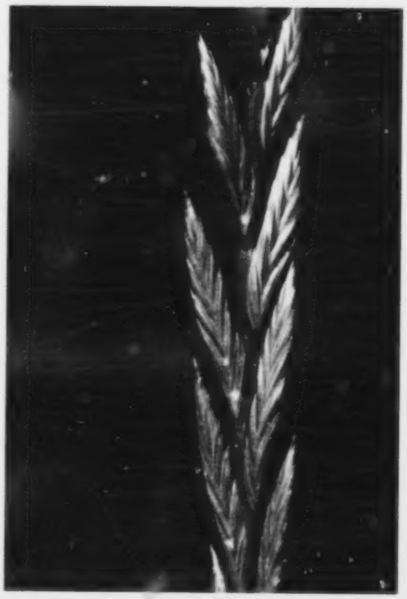


PERENNIAL RYEGRASS SEED HEAD

The slender seed head is a spike up to about 25 cm (10 in.) long with alternating spikelets attached edgewise to the stem (rachis). There are many spikelets, each with 3 to 10 flowers that are cross-pollinated. Lemmas are generally awnless.

GROWTH AND DEVELOPMENT

Perennial ryegrass germinates quickly, has excellent seedling vigour, establishes very fast and is productive in the year of seeding. It is less aggressive and slower developing than annual ryegrass. Under very good conditions, it can be used for pasture about two months after seeding but usually requires longer.

Established stands of perennial ryegrass begin growth in early spring, produce a dense growth of shoots and develop seed heads. Regrowth is excellent, and growth continues well into fall, provided growing conditions are favourable.

With favourable moisture and nitrogen fertility, established perennial ryegrass is vigorous and competitive, but less so than annual ryegrass. Perennial ryegrass is fairly compatible with clovers and alfalfa.

Perennial ryegrass has poor winter survival in Alberta and is usually grown as an annual. It will survive under favourable winter conditions in Alberta, but is short lived at best. Varieties vary in hardiness.

YIELD AND QUALITY

Perennial ryegrass produces good pasture yields but requires very good fertility for best performance. Protein and energy content are considered to be among the best of the grasses, and it is very palatable in the vegetative stages.

A fungal endophyte, somewhat similar to that in tall fescue, can be present in perennial ryegrass, especially turf types. Seed companies can provide information regarding the amount of endophyte in their varieties. The main toxin involved is lolitrem B, and limited testing in the Peace River area has shown it can be present in perennial ryegrass seed crop straw in amounts that could cause grass staggers. Grass staggers affects cattle, sheep and horses, and precautions need to be taken when grazing seed fields and feeding straw and seed screenings, especially with turf types.

ADAPTATION

Perennial ryegrass is best adapted to areas with cool summer temperatures, good moisture supply without summer drought and mild winters. It is grown as an annual in Alberta, surviving winter only under favourable conditions in irrigated and higher precipitation areas of the Black and Gray Wooded soil regions. Perennial ryegrass generally does best on clay or loam soils, since sandy soils often have limited moisture. It has good acid tolerance but does best on a soil that is neutral or mildly acidic. It has fair tolerance to salinity.

Perennial ryegrass has poor drought tolerance. It does best on well-drained soil, has good tolerance of excess soil moisture in the root zone and will only tolerate short-term flooding.

LIMITATIONS

Lack of winter hardiness is the greatest limitation for use of perennial ryegrass in Alberta. It can be used as an annual. It has poor tolerance to drought, and productivity is very low during drought. It is intolerant of excessive heat.

HAY AND SILAGE

Perennial ryegrass is poorly adapted to harvesting as it is low growing and the basal leaves result in higher leaf losses. It is slow to dry in the field.

Quality is very good at the heads-emerging stage and satisfactory for most uses until the flowering stage. A cutting height of 7.5 cm (3 in.) is satisfactory. It regrows quickly, providing additional forage later in the season.

PASTURE

Perennial ryegrass has excellent tolerance to close and frequent grazing, making it suitable for either rotational or continuous grazing. Initial spring growth withstands grazing at earlier stages than most grasses and can be grazed to a height of about 5 cm (2 in.). It yields well with fairly close, frequent grazing as it responds by producing a high tiller (shoot) density. Regrowth is rapid provided moisture and fertility are favourable. The roots provide good treading resistance once a stand is well established.

Perennial ryegrass can be grazed at a height of about 15 to 20 cm (6 - 8 in.) and grazed closer than many other grasses, i.e. to a height of about 5 cm (2 in.).

The shoots are soft, with excellent palatability for livestock, provided it is not headed. Animal gains are good, and high quality makes it suitable for high producing livestock, such as yearling beef cattle.

Timothy

INTRODUCTION

Timothy (*Phleum pratense* L.) is a widely adapted cool season perennial grass of European origin, although early introductions to Canada often came from the United States. It was grown in Canada before 1800 and is now commonly used in all but the drier areas of the province.

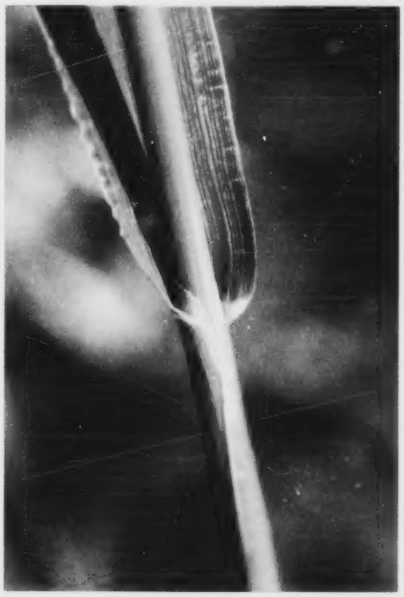
TIMOTHY PLANTS

Use in Alberta

Timothy is an adapted, reliable, very hardy and frequently grown perennial grass in the higher rainfall areas of the Gray Wooded and Black soil zones and irrigated areas of Alberta. It is easily established, compatible in mixtures and is used for domestic and export hay as well as pasture. Timothy is often grown with alsike clover in the Gray Wooded soils in Alberta. This grass is palatable to livestock. Intolerance of drought is its most serious weakness.

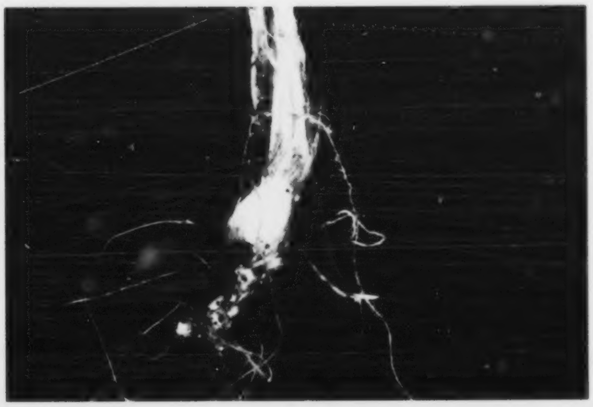
DESCRIPTION

Timothy is a perennial grass with erect, leafy stems up to about 1.2 m (4 ft.) height. Leaf sheaths are hairless and open with overlapping margins near the blade. Leaves are rolled in the bud stage, and when fully expanded, they are distinctly but finely veined, fairly wide (up to 12 mm), flat, often twisted, soft, hairless, rough on the margins and have pointed tips. There is a prominent, notched ligule, up to 4 mm or more in length, but no auricles.



TIMOTHY LEAF

Timothy roots are fibrous and shallow, but wide spreading, with a heavy concentration in the top 7.5 cm (3 in.) of the soil (see Table 6). Timothy has a bunch growth habit and does not form continuous sod.

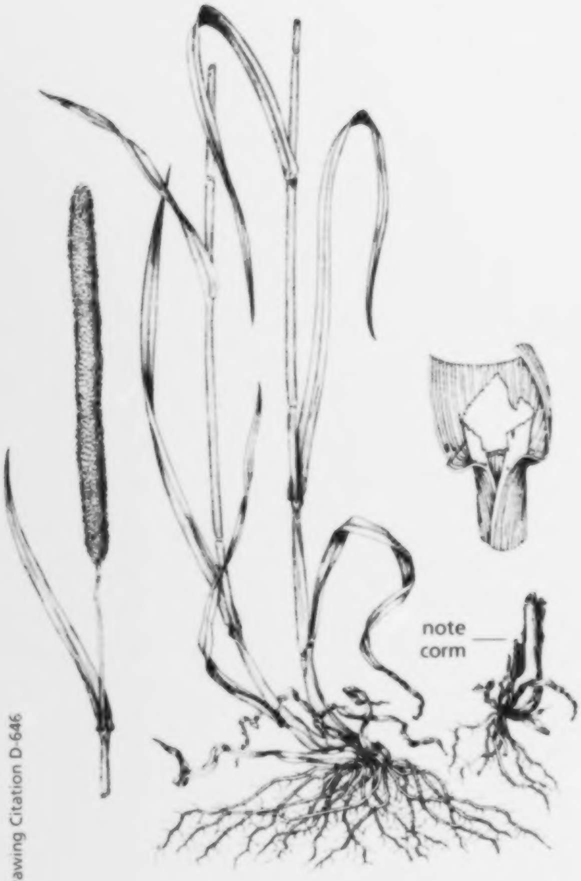


TIMOTHY CORM

Bulb-like haplocorms develop a centimeter below ground level, at the base of the stem, appearing as a swollen stem base and are a good characteristic for identification. The corms store and release carbohydrates as required for growth and survival, and by the time of flowering, they are well developed, with a new corm bud. After the first cutting, the new corm buds develop and produce regrowth; the old shoot and old corm die. New corms develop again in fall, survive winter and initiate growth the following spring.

The spike-like seed head is a dense, stiff and slightly bristly panicle, up to15 cm (6 in.) or more long. It is cross-pollinated and has one very small, dense seed per spikelet. The lemma and palea are thin, silvery and loosely attached, and the seeds are light brown.

FIGURE 30
Timothy



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TIMOTHY SEED HEAD

TIMOTHY FLOWERING

GROWTH AND DEVELOPMENT

Timothy seeds germinate quickly even with fairly cool temperatures and have good vigour but are very shallow rooted. Timothy seeds are very small and must be seeded very shallow to ensure establishment. Drought or high temperatures during the establishment period result in failure, although seeds and seedlings tolerate short-term flooding.

Timothy seedlings are not especially competitive with other plants although the crop is easily established. First-year plants usually develop one shoot (tiller), which may produce a seed head. Full yield potential is normally reached the year following seeding.

Spring growth of timothy occurs about the same time or slightly later than most grasses, with a flush of shoots that have a high proportion of seed heads. It produces fewer shoots than most grasses. There is some difference in heading dates and maturity between varieties. Regrowth develops slowly, especially if timothy is harvested during stem elongation when growing points are elevated or before new shoots (tillers) appear at the base of headed plants. Growing points elevate in the regrowth and will produce heads.

Timothy varieties vary in regrowth ability, but have a poor distribution of growth, with most production being early in the season. It is best suited to a single cutting of hay with the regrowth being grazed. It should be rested or used lightly in fall.

Timothy is not competitive, and bare ground between plants allows invasion by other plants and weeds. It is compatible with other forage species and is commonly used in mixtures, often with alsike clover or other legumes and grasses. Legumes may persist longer with timothy than with smooth bromegrass because timothy is not creeping or aggressive. Timothy has excellent cold tolerance (Table 10) and good longevity, especially in cool, higher rainfall areas. Under favourable growing conditions, new seedlings may establish from seed that sets and shatters in an existing stand.

YIELD AND QUALITY

Timothy has good yield potential, particularly in the higher rainfall regions and moist areas. Quality is similar to other grasses although protein content may be low and can be limiting in more mature forage. It is very palatable as hay and pasture.

Timothy

ADAPTATION

Timothy is best adapted to the cooler regions of Alberta including the higher rainfall areas of the Gray Wooded and Black soil regions. It can be grown in irrigated areas although it has low tolerance to very hot weather. Timothy does well on clay, silt and peat soils. It grows on sandy soils only if there is sufficient moisture. It does better than many other grasses on less fertile soils but does best with good fertility. Timothy has good tolerance of acidity, tolerating pH 5.0 with reduced yields. It has poor tolerance of salinity and alkalinity.

Timothy is shallow rooted and has poor drought tolerance, being intolerant of even short periods of moisture stress. It has good tolerance to soils with excess moisture in the root zone and will withstand short-term flooding during the growing season. Timothy has excellent tolerance of spring flooding.

LIMITATIONS

The most serious limitation of timothy is lack of drought tolerance due to its shallow roots. Even short periods of drought, which can occur in the Black and Gray Wooded soil regions, will result in reduced production. It is intolerant of very high temperatures.

Timothy is difficult to manage for pasture. It should not be grazed too early or too close, is sensitive to grazing during stem elongation and regrows poorly, resulting in a poor distribution of yield.

HAY AND SILAGE

Timothy is very well suited to a two-cut harvesting system, with the second cutting being much lower in yield than the first, and it is often grazed. Including a legume with good regrowth characteristics, such as alfalfa, results in good second cuttings.

Harvesting the first cut between the fully headed and the blossom stages gives good yield and high quality hay. At this stage, the bottom leaves have died from shading, but the plants have high food reserves, and new leaf buds have initiated growth. Timothy is well suited to hay and silage harvesting as it is lodging resistant, easy to harvest and easily dried in the swath.

Timothy hay is also produced for export to Asia where it is used as a fiber source for dairy cattle. High protein and energy are not required for these markets. They prefer tall, coarse plants with long heads and large leaves. The preferred final product is light green and free of dust and mold. Exporting companies should be contacted to obtain present market requirements and to determine protocols, which may affect exports.

PASTURE

Timothy is commonly used for pasture in western Alberta, and despite not being well suited to grazing, it is fairly productive in the initial years of a stand. Yield is high in late spring and early summer but low in midsummer and fall. Some varieties regrow slightly better than others, making them more suitable for pasture.

Timothy has only fair tolerance to frequent or close grazing. It does not develop a continuous sod, and soil may be subject to treading damage, especially if the soil is very soft.

There is a short period when timothy can be grazed to minimize affecting the stand. It is especially sensitive to grazing in the stem elongation period, which results in slow regrowth and weakens the stand. It should be grazed quickly and a long rest period provided between grazings. This objective is most easily accomplished using rotational grazing. Timothy is usually less productive under continuous grazing, and with continuous, close grazing, it is quickly dominated by grazing resistant invader species, such as Kentucky bluegrass.

A minimum of about 10 cm (4 in.) of green, leafy residue should remain after grazing timothy. It should be grazed lightly in the fall to enable the accumulation of food reserves for winter. Timothy can be grazed in the fall dormant season, although protein content may be low.

Timothy has excellent palatability for grazing livestock in the vegetative stage, but it is low in palatability and poorly utilized after heading.

Crested Wheatgrass

INTRODUCTION

The two commonly used species of crested wheatgrass include *Agroypron cristatum* (L.) Gaertner and *Agropyron desertorum* (Fisch ex Link) Schultes, which is more adapted to the driest regions. The two species are closely related but do not cross readily, although hybrids have been developed.

CRESTED WHEATGRASS PLANT

Crested wheatgrass is an introduced perennial grass that is prevalent in the semi-arid regions of the Canadian prairies. It is native to parts of Europe, the Middle East, Russia, Northern China and Mongolia. Early introductions to Canada were *A. cristatum* diploids [Fairway types] from western Siberia. The Fairway variety, licensed in 1932 by the University of Saskatchewan, was the first Canadian variety.

Agropyron cristatum varieties commonly used include diploid types (e.g. Fairway) and tetraploid types (e.g. Kirk). *Agropyron desertorum* varieties commonly used are tetraploid types (e.g. Nordan) and are known as standard type. The diploid types have broader crowns, more but smaller tillers (shoots) and are less upright compared to the tetraploid types, making them better suited for pasture than hay, especially Fairway. Varieties within and between types have over-lapping characteristics, and the choice of type and variety should include consideration of regional adaptation, especially long-term yield.

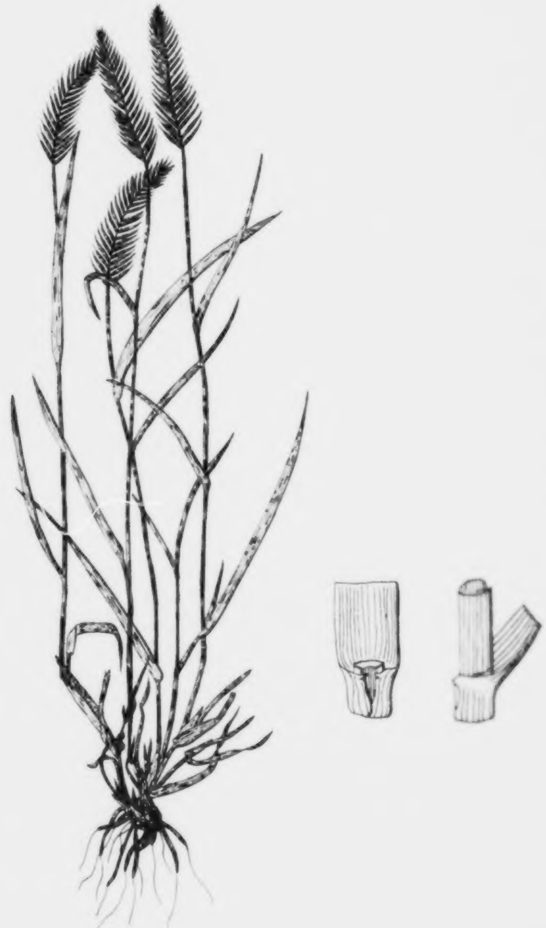
Use in Alberta

All combinations of species and types are used in Alberta as they are extremely hardy and long lived, with good adaptation to the semi-arid regions. They are best adapted to the climate of the Brown and Dark Brown soil regions. Crested wheatgrass is most used for spring pasture and hay. Limitations to use include very low palatability in more mature stages and its ability to invade into native grassland.

DESCRIPTION

Stems are erect and of medium height, commonly 50 to 80 cm (20 to 30 in.) tall depending on variety and growing conditions. Plants are quite variable and may be fine stemmed and leafy or coarse with fewer leaves.

FIGURE 31
Crested wheatgrass



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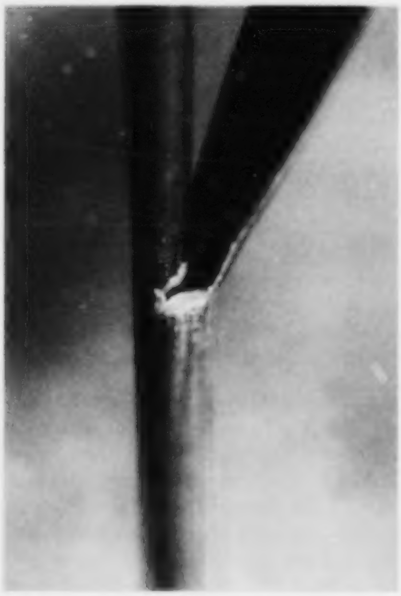
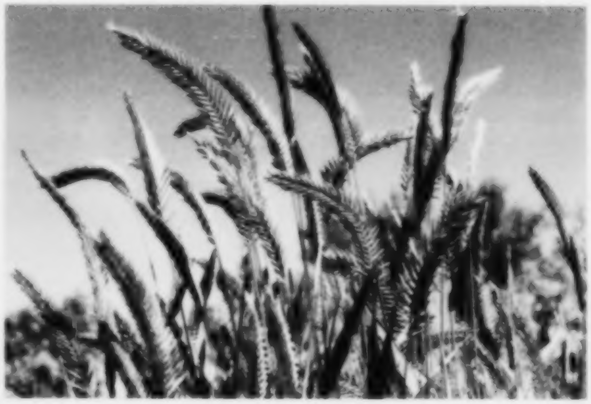
Leaf sheaths are open (split) with overlapping margins and may have soft hair near the base of shoots. Leaf blades are rolled in the leaf-emergence stage, commonly to 5 mm wide but may be up to about 8 mm wide. The blades are flat with rough margins, finely but distinctly veined on the upper surface and taper to a sharp point. Fairway types have small, dense hairs on the upper surface of leaves while standard types do not. The small auricles (to 1.5 mm length) are variable, usually claw-like but may not be fully developed. The ligule is small, up to 1.5 mm long.



CRESTED WHEATGRASS LEAF

Crested wheatgrass is a bunchgrass with a dense, very deep, fibrous root system. Plant circumference increases slowly with age due to new shoots (tillers) forming on the outside of the crown. Roots may penetrate soil to below 3 m (10 ft.).

The short, flat spike (seed head) of about 7 cm (2 3/4 in.) length and 2.5 cm (1 in.) width is the most striking identification feature of crested wheatgrass. Spikelets are closely spaced at a wide angle on opposite sides of the stem (rachis), giving the heads a crested or comb-like appearance. Spikelets are up to 1.5 cm (5/8 in.) in length, have 5 to 7 flowers and are cross-pollinated. Glumes are awn tipped, and lemmas may or may not have a short awn. The seed shatters easily. Diploid types have smaller seeds than standard types.



CRESTED WHEATGRASS SEED HEADS

GROWTH AND DEVELOPMENT

Crested wheatgrass seed germinates and establishes quickly if conditions are favourable. It has a reputation for establishing satisfactorily under less than ideal conditions, and seeds may remain in dry soil until moisture is satisfactory for germination. It is best to seed when conditions are moist and cool. The seedlings are very vigorous but sensitive to competition and should be given a season to establish before grazing. Seedlings are aggressive enough that under favourable conditions, volunteer plants can establish into native grassland from seed that is spread from adjacent tame stands.

Crested wheatgrass is very early growing in spring with most of its production occurring in a flush of growth in May and June. It heads early. Except for early grazed pasture, regrowth ability is poor, making for a poor distribution of growth.

Established crested wheatgrass is strongly competitive with other forages and weeds. It grows well with drought tolerant legumes such as alfalfa, and mixtures yield more than crested wheatgrass alone.

Crested wheatgrass has excellent hardiness and is among the most cold tolerant forage grasses on the Canadian Prairies (see Table 10). It has excellent longevity in the driest areas of the province, being more or less permanent, but it does not persist well in the more moist regions of the Black and Gray Wooded soils.

TABLE 10
Cold hardiness of spring-seeded grasses in late October at Saskatoon, Saskatchewan

Grass Species	Variety	Temperature (°C) for 50% Survival (Lt 50) Seeded Mid-May	Seeded Late August
Reed Canarygrass	Frontier	-23	-19
Orchardgrass	Kay	-23	-18
Altai Wildrye	Prairieland	-28	-20
Meadow Bromegrass	Regar	-23	-19
	Paddock	-22	-22
Northern Wheatgrass	S-8895	-30	-21
Smooth Bromegrass	Carlton	-28	-22
	Baylor	-28	-22
Russian Wildrye	Swift	-31	-23
Creeping Red Fescue	–	-30	-22
Tall Wheatgrass	Orbit	-27	-23
Intermediate Wheatgrass	Clark	-27	-24
Timothy	Climax	-28	-25
Slender Wheatgrass	Revenue	-30	-25
Western Wheatgrass	S-8580	-31	–
Crested Wheatgrass	Fairway	-32	-28
	Kirk	-35	-28
	Nordan	-30	-27
Kentucky Bluegrass	Dormie	-37	–
Winter Wheat	Norstar	–	-24
Fall Rye	Puma	–	-31

Lt 50 is the lethal temperature that kills 50% of the plants

Adapted in part from Limin and Fowler 1987

YIELD AND QUALITY

In dryland areas, crested wheatgrass yields among the highest of the tame grasses for hay, based on one harvest per season. Its main advantage for pasture is its very early spring production. At Lacombe, crested wheatgrass showed good early and total production compared to other species, based on four cuts per year. However, regrowth yield was relatively less as the season progressed (see Table 11). In the Brown soil area, crested wheatgrass can produce twice as much forage as native grasses.

Crested wheatgrass has very good nutrient quality early in the season. However, it heads early with protein content and palatability dropping off quickly after blossoming as the plants mature and the bottom leaves die off. It is advantageous to harvest it at an early date.

TABLE 11
Yield distribution of grasses cut four times per year at Lacombe, Alberta

	Dry Matter Yield (t/ha) Averaged Over Two Years				
Species	Cut 1 June 1-2	Cut 2 July 6-8	Cut 3 Aug. 14-15	Cut 4 Sept. 13-14	Total
Meadow Brome	4.7	2.6	3.5	1.7	12.5
Smooth Brome	4.1	2.7	3.1	0.5	10.4
Meadow Foxtail	5.0	1.5	2.0	1.3	9.8
Orchardgrass	2.5	3.1	3.1	1.7	10.4
Crested Wheatgrass	5.2	2.6	2.3	0.7	10.8

Adapted from Baron et al 1989

ADAPTATION

Crested wheatgrass is adapted to the Brown and Dark Brown soil areas and other dry sites of Alberta. A. *cristatum* is considered to be more adapted to, and more persistent in the moister climate of the Dark Brown soils than the Standard type which has greater drought tolerance. Crested wheatgrass grows well on deep, fertile soils to dry, shallow soils, and on sand, silt or clay. It has fair tolerance to acidity. It has good tolerance to salinity, but less than tall and slender wheatgrass or Russian and Altai wildrye grass.

Crested wheatgrass is well known for its excellent drought tolerance, similar to Russian wild ryegrass, and is best suited to semi-arid regions that have spring moisture, followed by a dry summer. It escapes drought by growing quickly in early spring, before most droughts occur. Crested wheatgrass responds to drought by the drying down of older leaves to reduce leaf area. Under extreme drought, it will go dormant. It is slow to resume growth following drought, making it less suitable for areas that are intermittently dry and moist.

Crested wheatgrass has poor tolerance to excessive soil moisture and high water tables in its root zone and is not adapted to moist sites. It has poor tolerance to flooding except for short durations during spring break-up.

Crested wheatgrass is used for dryland lawns and areas requiring little or no maintenance. It can also be used for re-vegetating rights of ways, etc. where its ease of establishment, excellent longevity and competitiveness with weeds are beneficial, but its ability to invade into adjacent native prairie is a concern.

LIMITATIONS

Crested wheatgrass provides a poor distribution of production for pasture. Other than very early in spring, regrowth is slow growing, resulting in low productivity in summer. After heading, initial growth is unpalatable, and grazing animals avoid it, creating unpalatable tufts in pastures.

HAY AND SILAGE

Crested wheatgrass is early maturing and yields well for hay in dry regions. Assuming fertility is not limiting, annual hay yield is closely related to the April and May moisture conditions. Regrowth yield from hay fields is low yielding but suitable for fall grazing.

The maturity of crested wheatgrass advances very quickly, and it is ready to harvest at an early date. Hay quality is good provided it is cut at about the heading stage or soon after heading.

Crested wheatgrass generally stands up well and is easy to harvest. Suitability for hay and silage production is fair to good as lower growing, finer stemmed types are less suited to machine harvesting than taller types.

PASTURE

Crested wheatgrass, especially the low growing Fairway type, is commonly used for dryland pasture. It is most useful as early season pasture, providing good yields of nutritious forage before other tame or native pastures are ready, beneficially deferring use of these other pastures until they are ready to be grazed.

Crested wheatgrass has excellent tolerance to early spring grazing and to close grazing. It should be grazed heavy enough to keep plants vegetative since headed plants are coarse and unpalatable. Except for very early spring, crested wheatgrass has poor regrowth ability, requiring a long rest period. It withstands heavy trampling.

Both rotational and continuous grazing systems can be used with crested wheatgrass. Plants that are grazed in early spring regrow well so that rotation to another pasture before they can be grazed a second time is beneficial. It can be grazed at earlier stages than most grasses. Grazing down to a 5 cm (2 in.) height and 70 per cent utilization is satisfactory.

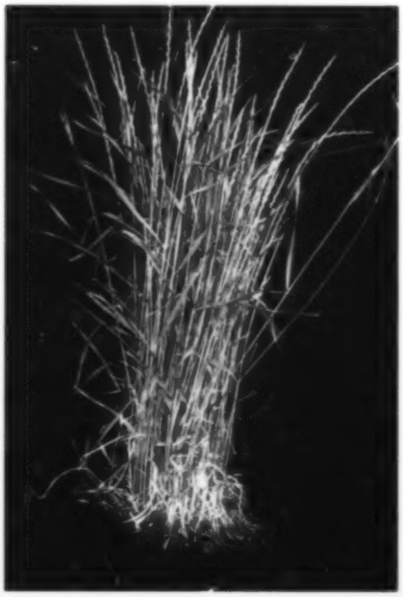
Crested wheatgrass regrowth can be stockpiled for fall grazing although protein is likely to be low (see Table 8).

Crested wheatgrass has excellent palatability in early spring, and livestock do well on it. By early summer, once it heads out, the forage is less palatable than most other grasses, making it difficult to manage in pasture mixtures.

Intermediate and Pubescent Wheatgrass

INTRODUCTION

Intermediate wheatgrass (*Elytrigia intermedia* (Host) Nevski) is an introduced species from Europe and Asia. Early varieties used in Canada originated from Russia, some by way of the United States.



INTERMEDIATE WHEATGRASS PLANT

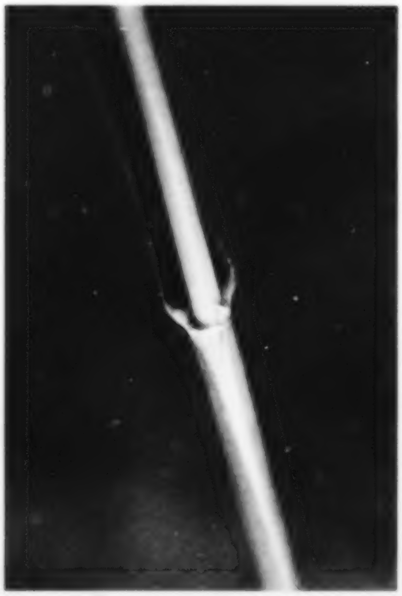
Pubescent wheatgrass was once thought to be a separate species but is now considered to be a type of intermediate wheatgrass. Pubescence refers to the presence of dense, short hair, which can be present on heads.

Use in Alberta

Intermediate wheatgrass is used for hay and pasture in Alberta. It is adapted to the Dark Brown, Black, Gray Wooded and irrigated soil regions, is easy to establish and yields well but is limited by medium longevity.

DESCRIPTION

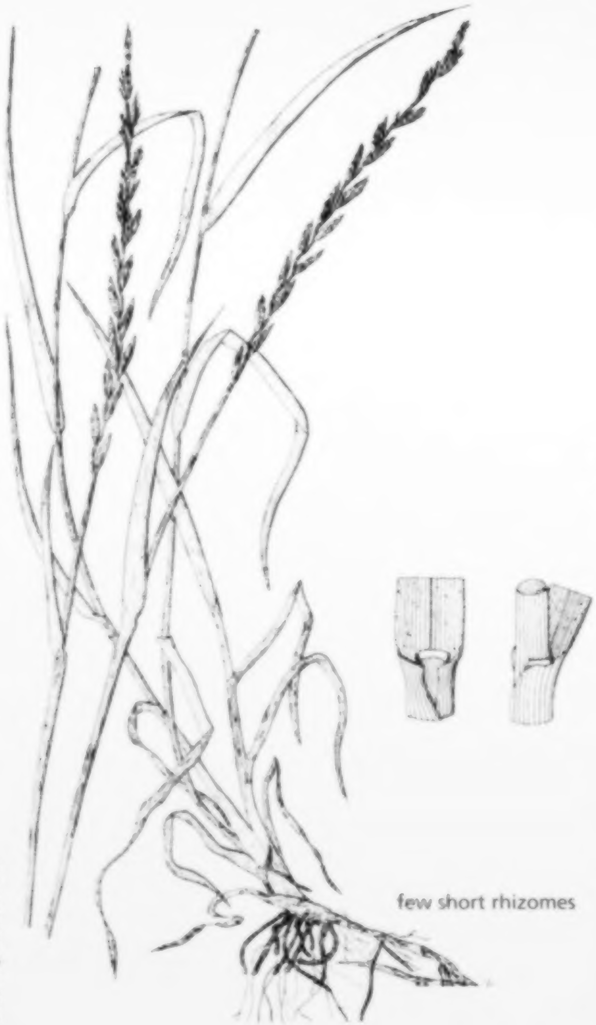
Intermediate wheatgrass has erect, strong, smooth stems and is quite tall, reaching a height of about 1.5 m (5 ft.) under favourable conditions. Leaf sheaths are hairless and open at the top. Sheaths and blades vary from blue-green (glaucous) to green. Leaf blades are flat or loosely rolled inward, 5 to 10 mm wide and taper to a sharp point. Intermediate types have hair on the surface and on the leaf margins (edges). Leaf blades are veined with a mid-vein visible on the underside. Auricles are rudimentary or slender and clasping while ligules are very small, up to 1 mm long.



INTERMEDIATE WHEATGRASS LEAF

Intermediate wheatgrass has a deep, extensive, fibrous root system. It has short rhizomes, which develop a tough sod, especially under good moisture conditions. Plants may appear somewhat bunched, especially under dry conditions. Some varieties have stronger rhizomes than others.

FIGURE 32
Intermediate wheatgrass



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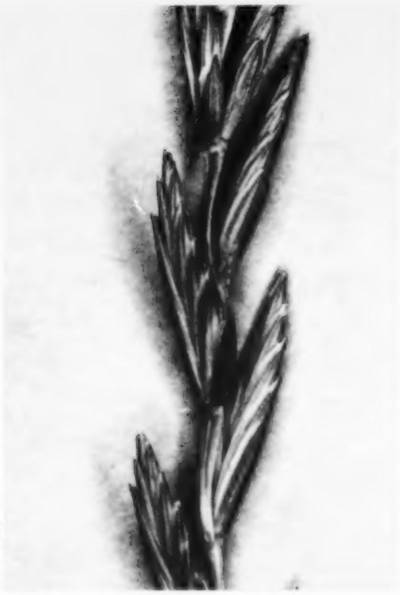
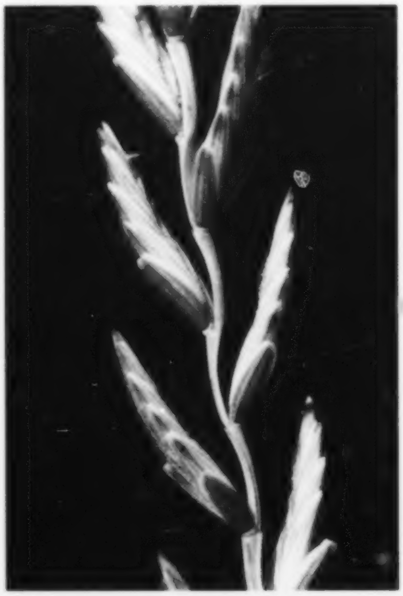

Colin Stone

CLOSE-UP OF INTERMEDIATE WHEATGRASS SEED HEAD



CLOSE-UP OF PUBESCENT WHEATGRASS SEED HEAD

The head is a narrow spike, about 15 to 25 cm (6 - 10 in.) long. Spikelets are attached alternately, one per node, overlap slightly, are positioned close to the stem (rachis) and usually have two to six flowers. Glumes and lemmas may have short, stiff, dense hair (pubescent form), and lemmas may have short awn tips. Intermediate wheatgrass is cross-pollinated, producing relatively large seed.

TABLE 12
Dry matter yield of grasses at Pathlow, Saskatchewan, 1982 – 1984

Species	Two Cut Yield (kg/ha)	Multiple Cut Yield (kg/ha)
Smooth Bromegrass	1,900	1,480
Crested Wheatgrass	2,000	1,540
Intermediate Wheatgrass	1,670	1,470
Altai Wildrye	1,520	1,340
Meadow Bromegrass	2,040	1,880
Russian Wildrye	1,240	1,290

Adapted from McCartney et al 2004

GROWTH AND DEVELOPMENT

Seedlings of intermediate wheatgrass are vigorous, and they establish easily and quickly. This forage is fairly tolerant of companion crops although they should be managed to reduce competition.

Intermediate wheatgrass is a tall growing grass that flowers later than smooth bromegrass and crested wheatgrass. Later maturity may be an advantage as it matches the maturity of legumes (especially alfalfa) quite well. It has a poor distribution of growth with highest production in spring and early summer. Regrowth is fair in spring but poor in summer and fall. Intermediate wheatgrass is sensitive to cutting in the shot blade stage.

Intermediate wheatgrass is not overly competitive, and legumes, such as alfalfa, grow well with it. It is a perennial grass with good winter hardiness (see Table 10) but only fair longevity, usually providing four to six years of productive stand life.

YIELD AND QUALITY

Intermediate wheatgrass is high yielding (Table 12 and 13) with quality more or less similar to other grasses. Later maturity helps maintain quality to some extent, but quality drops off quickly with advancing maturity as it tends to get stemmy.

ADAPTATION

Intermediate wheatgrass is adapted to Dark Brown, Black and Gray Wooded soil regions, including irrigated areas of Alberta. It will grow on all soil textures, depending on other factors such as rainfall and drainage. Intermediate wheatgrass has poor tolerance of acidity and good tolerance to salinity. Pubescent types are thought to be more saline tolerant.

Intermediate wheatgrass has good drought tolerance. It is more drought tolerant than smooth bromegrass but less than crested or western wheatgrass. Pubescent types are considered to be more drought tolerant than intermediate types. It has only fair tolerance to spring flooding and excess moisture in the root zone or flooding during the growing season. Intermediate wheatgrass is best adapted to soils with good internal moisture drainage.

LIMITATIONS

Longevity has limited the use of intermediate wheatgrass. Poor tolerance to close or frequent grazing limits its usefulness for pasture.

HAY AND SILAGE

Intermediate wheatgrass has excellent suitability for hay production and produces high yields and good quality. It is most suitable for a single cutting of hay or silage, with regrowth being used for grazing after the end of the growing season.

It matures later than smooth bromegrass and crested wheatgrass. In mixtures, haying should be done at the correct time for the legume, provided intermediate wheatgrass is headed. Pure stands of intermediate wheatgrass should be harvested from early heading to the flowering stage, providing a good compromise between quality and yield. As maturity advances, it becomes stemmy, and quality drops off quickly.

Intermediate wheatgrass has good lodging resistance and is easy to harvest. It should not be cut lower than 10 cm (4 in.) in height.

PASTURE

Intermediate wheatgrass can provide high yielding pasture if it is well managed. Its yield distribution is only fair with slow regrowth, except in spring (e.g. early June). It has only fair tolerance to grazing. It is intolerant of close or frequent grazing, and initial spring growth should be grazed before stem elongation, making for a short time for grazing, but improving regrowth. The sod has good resistance to treading.

Light grazing is required, generally with long rest periods, making intermediate wheatgrass more manageable using rotational grazing. At least 10 cm (4 in.) of leafy residue should be left after grazing. It should be rested or grazed very lightly during the last four to six weeks of the growing season. Leaves are fairly resistant to fall frost, and regrowth can be grazed after hard frosts have occurred.

Northern and Streambank Wheatgrass

INTRODUCTION

Northern wheatgrass (*Elymus lanceolatus* (Scribn. & Smith) Gould) is a long-lived grass that is native to and is widely distributed in Canada and the United States. In the United States, it is known as thickspike wheatgrass. Northern wheatgrass is a constituent of native prairie in southern Alberta and on river slopes in northern Alberta. The Canadian variety Elbee was developed from native stands on the Alberta and Saskatchewan prairies. Northern wheatgrass is very similar in appearance to western wheatgrass but can be identified by leaves that are held at less than 45 degrees relative to the stems and are usually greener, have yellowish auricles, shorter glumes and the lemmas are not rigid.

NORTHERN WHEATGRASS PLANT

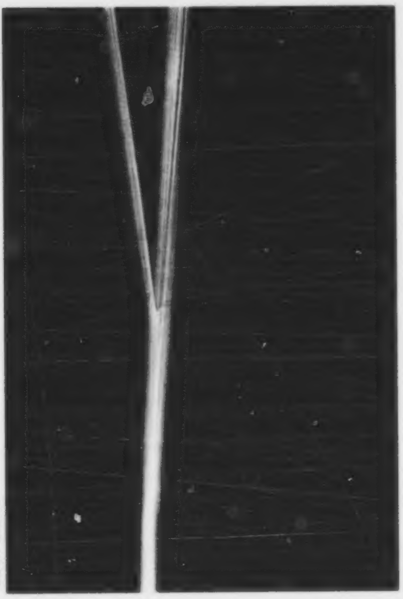
Streambank wheatgrass, now considered to be a sub-species of northern wheatgrass, is low growing with tough, narrow, smooth leaves and non-pubescent (non-hairy) heads. It is more aggressively creeping and less productive than the northern wheatgrass types and is used mainly for reclamation. Low growing northern wheatgrass types have also been developed.

Use in Alberta

Northern wheatgrass is adapted to Brown, Dark Brown, Black and Gray Wooded soil regions. It is very drought tolerant and long lived but produces modest yields. It establishes fairly well from seed and is mainly used agriculturally for dryland pasture, such as the re-seeding of depleted rangeland. It is mainly used for reclamation of disturbed sites in dryland areas.

DESCRIPTION

Northern wheatgrass has fine, erect, rough stems to about 75 cm (30 in.) in height, but is usually much shorter, with quite low growing vegetation. Leaf sheaths are smooth or slightly rough and open with overlapping margins. Leaves are stiff, erect, flat or rolled inward, up to 6 mm wide and have sharp pointed tips. They are dull green or slightly blue-green, strongly veined on the upper surface but smooth on the bottom side. Under dry conditions, the leaves roll tightly and may be "wiry." Auricles are clasping and about 2 mm long while ligules are less than 1 mm long.



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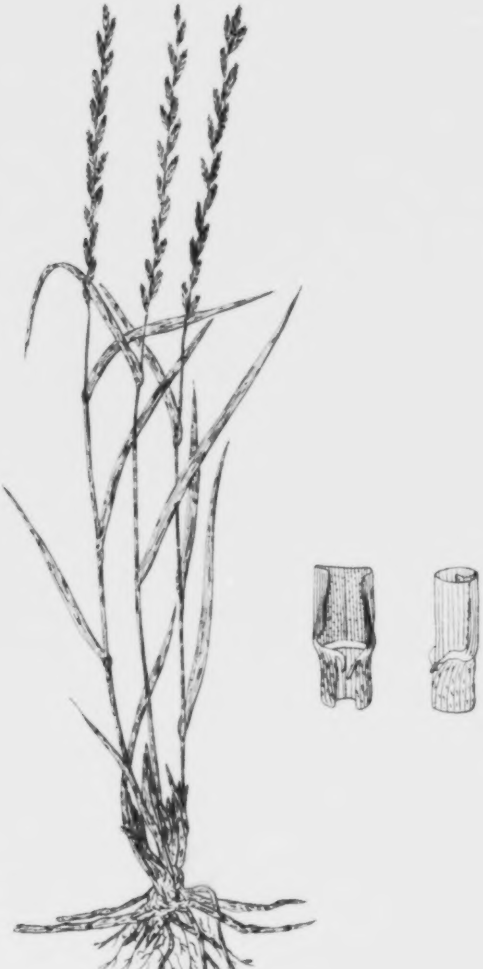
NORTHERN WHEATGRASS LEAF

Northern wheatgrass develops a very dense mass of roots in the upper soil layer and also has deep soil penetration. Rhizomes are long and enable it to spread, but it is not as aggressive as western wheatgrass. Low growing types are more strongly rhizomatous.

FIGURE 33
Northern wheatgrass



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Seed heads (spikes) are slender, erect and about 6 to 15 cm (2 1/2 to 6 in.) or more in length. Spikelets overlap slightly to closely, usually have three to eight flowers and are cross-pollinated. Glumes are not rigid, 6 to 9 mm long, may have a short awn tip and are rough or finely hairy. Seeds are about 1 cm (3/8 in.) long, pubescent (hairy) and lemmas may or may not have a short awn tip.

NORTHERN WHEATGRASS SEED HEAD

The streambank wheatgrass type is similar but the leaf blades are narrower (to 3 mm wide), and the heads do not have awns or pubescence.

GROWTH AND DEVELOPMENT

Seedling vigour and ease of establishment of northern wheatgrass are good, but weed control is needed. It establishes easier than western wheatgrass but not as aggressively as most introduced (tame) grasses. Rhizomes thicken the stand, usually giving good ground cover after a year's growth.

Initial spring growth of northern wheatgrass begins sooner than western wheatgrass, occurring from early spring to early summer, but it develops somewhat slower than introduced (non-native) grasses. Established stands are mainly vegetative and may thicken, becoming less productive. It has fair regrowth ability.

Established northern wheatgrass is competitive. It is compatible with other species but can be dominated by aggressive species. Northern wheatgrass has excellent hardiness and longevity, similar to other very hardy grasses (see Table 10).

YIELD AND QUALITY

Northern wheatgrass produces very modest forage yields and on average, considerably less than introduced grasses (see Table 13). Total yield with multiple cuttings is low, but distribution of growth is fair.

The quality of northern wheatgrass is typical of grass, being very good in the vegetative stage and decreasing with maturity. The initial spring growth does not retain quality as well into fall as some grasses, such as western wheatgrass, but regrowth quality is good.

ADAPTATION

Northern wheatgrass is very variable, and specific traits can be selected from native grasslands. It is adapted to the Brown, Dark Brown, Black and Gray Wooded soil zones and is adapted to clay, silt and sandy textures. It has fair tolerance to acidity. It has good salt tolerance but less than slender and western wheatgrass and much less than tall wheatgrass.

Northern wheatgrass has excellent drought tolerance, more than western wheatgrass, and recovers quickly following drought. Spring flooding tolerance is good, but it is not tolerant of flooding during the growing season. It has only fair tolerance to excess soil moisture in the root zone.

Northern wheatgrass has dense root production and rhizome growth, enabling it to stabilize soil and control erosion. It is mostly used for reclamation purposes including seeding disturbed rangeland, oil leases, roadsides, pipelines, etc. that receive low maintenance and where this native grass is desirable. Low growing types, such as streambank wheatgrass, are especially useful for airports, lawns, machinery yards and recreation areas in dryland areas as they provide good sod and a non-bunchy growth habit.

LIMITATIONS

Modest yielding ability of forage types and especially low growing types is the most limiting aspect of northern wheatgrass agriculturally.

HAY AND SILAGE

Northern wheatgrass has poor to fair suitability for hay and silage production as it is not high yielding, especially low growing types. Streambank wheatgrass is low growing, hard to harvest and palatability of the hay has been noted as poor.

PASTURE

Northern wheatgrass is more adapted to pasture than to hay. It begins growth early in spring although it is best to defer grazing it until earlier growing species have been utilized. It has only fair regrowth ability.

Northern wheatgrass has only fair grazing tolerance, is intolerant of close, frequent grazing and recovers slowly. It should not be grazed until it is well established. The rhizomes and dense root system of northern wheatgrass give it good resistance to treading.

Rotational grazing enables deferring its use until after introduced species have been grazed. Grazing before stem elongation leaving about 10 cm (4 in.) of leafy residual material is satisfactory.

The palatability of northern wheatgrass to grazing livestock is good in the vegetative stage but not late in the season. Low growing types are less palatable than taller types. Regrowth vegetation is suitable for fall grazing.

Northern wheatgrass is common on native range in Alberta. It is a decreaser species in southern Alberta but an increaser in northern Alberta. Decreasers are well liked by livestock and will decrease under heavy grazing. Increasers will take the place of the decreaser species.

TABLE 13
Yield of wheatgrasses on dryland (kg/ha)

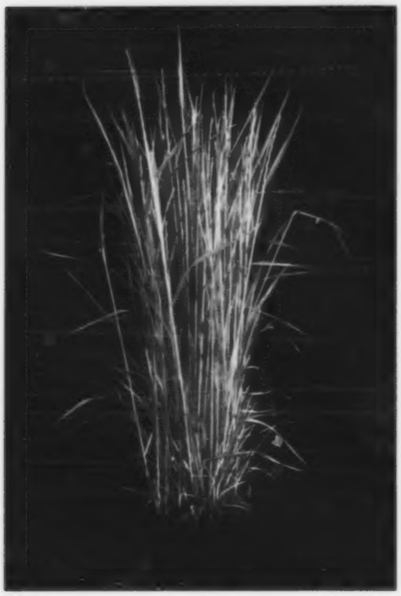
Species	Variety	Lethbridge, Alberta	Lacombe, Alberta
Western Wheatgrass	Walsh	1,670	7,368
Northern Wheatgrass	Elbee	1,628	7,004
Crested Wheatgrass	Summit	2,455	9,095
Pubescent Wheatgrass	Greenleaf	3,238	7,928
Intermediate Wheatgrass	Chief	3,330	8,668

Adapted from Anonymous 1982

Slender Wheatgrass

INTRODUCTION

Slender wheatgrass (*Elymus trachycaulus* (Link) Gould ex Shinners) is native to Canada and the United States and is widely distributed in native grasslands. Slender wheatgrass varieties have been selected from plants found on the Canadian prairies, and it was one of the first native grasses to be widely used as tame forage.



SLENDER WHEATGRASS PLANT

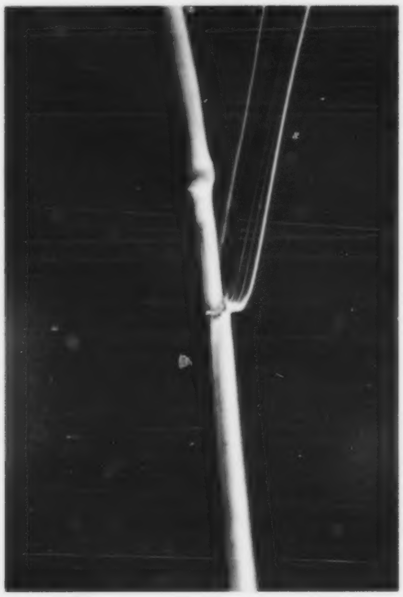
Bearded wheatgrass, also called awned wheatgrass, is considered to be a sub-species of slender wheatgrass. Compared to slender wheatgrass types, bearded wheatgrass has pubescent (hairy) sheaths that are visible in young shoots, wider leaves (to 10 mm) and the lemmas have long straight awns (beards).

Use in Alberta

Slender wheatgrass is adapted to all crop regions of Alberta, including irrigated areas, but not the lowest precipitation areas of the Brown soil zone. It is quick to establish, short lived and useful mainly for hay and to some extent for pasture.

DESCRIPTION

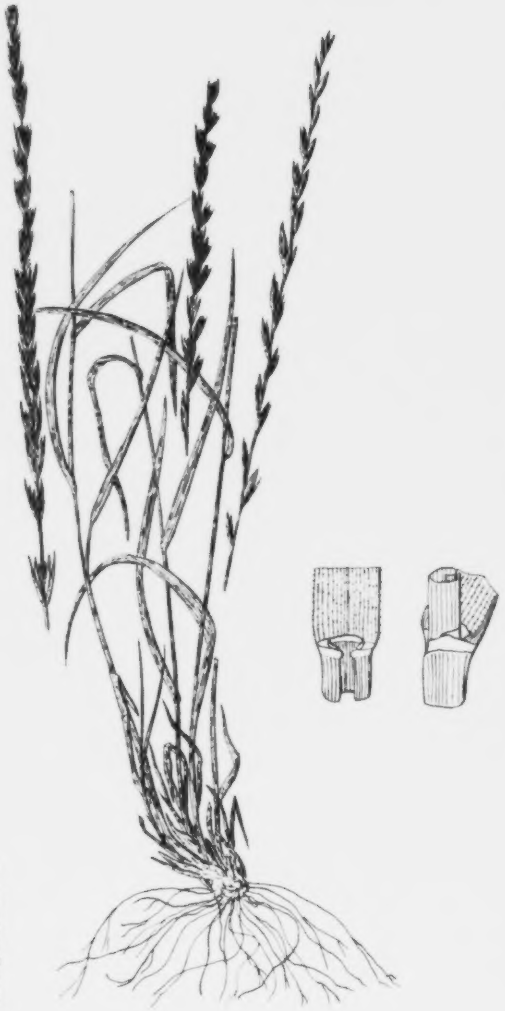
Slender wheatgrass is a diverse species with botanical characteristics and adaptation differing between various native stands and varieties. Stems are erect to 1 m (3 1/4 ft.) or more in height. Leaf sheaths are hairless, open and may be purplish at the base. Leaf blades are up to about 6 mm or more in width, flat in cross section, fairly long and taper to a sharp point. Leaves may be green or slightly blue-green, veins show on the upper surface of leaf blades and the margins (edges) are rough. Auricles are rudimentary, up to 1 mm long, not clasping and one or both may be absent. Ligules are rounded and less than 1 mm long. The collar is a yellowish green.



SLENDER WHEATGRASS LEAF

Roots are dense and fibrous. Slender wheatgrass has a bunch habit of growth although plants sometimes have short rhizomes. Individual plants in a new stand enlarge by producing many shoots (tillers).

FIGURE 34
Slender wheatgrass



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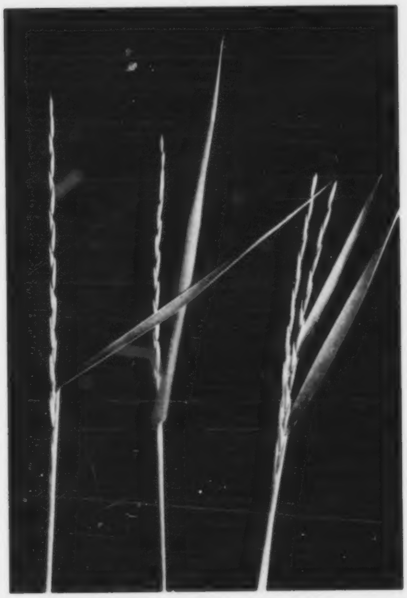
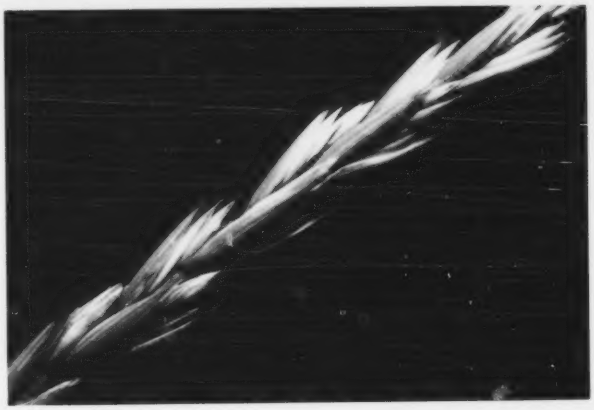
The heads (spikes) are erect or nodding, up to about 25 cm (10 in.) in length. Spikelets may or may not overlap each other, are up to 20 mm long and have 2 to 8 florets, which are self-pollinated. Glumes are up to about 12 mm long, almost as long as the spikelets and sometimes have a short awn tip. Lemmas are up to 15 mm long, without hairs and may have short awns. Seeds are quite large.



SLENDER WHEATGRASS SEED HEADS



SLENDER WHEATGRASS SEED HEAD CLOSE-UP

GROWTH AND DEVELOPMENT

Slender wheatgrass has excellent seedling vigour, is easy to establish and under favourable conditions, it can produce significant yields in the seedling year. It can provide erosion control very quickly because it establishes rapidly. It can re-seed naturally.

Slender wheatgrass grows quickly, beginning in early spring, with its main production occurring by early summer. Regrowth ability is fair.

Slender wheatgrass is not especially competitive. Young slender wheatgrass stands are the most vigorous while older stands are less competitive. Slender wheatgrass does well with alfalfa in short duration mixtures. It is sometimes seeded in mixtures with long-lived, slow establishing species, such as Russian or Altai wild ryegrass to increase production during the first few years of the stand. However, the slender wheatgrass may weaken the slower establishing species, decreasing their long-term yield.

Slender wheatgrass has excellent hardiness, comparable with other well adapted wheatgrasses (see Table 10). Longevity is fair, with a three to five-year stand life, unless re-seeding occurs. It persists less well under very dry conditions.

YIELD AND QUALITY

Slender wheatgrass is high yielding based on a single harvest and is very productive in short crop rotations. It yields less well based on multiple harvests. Quality is very good in spring but decreases quickly with advancing maturity as the plants become very stemmy.

ADAPTATION

Slender wheatgrass is adapted to the Dark Brown, Black, Gray Wooded soil zones and the higher precipitation areas of the Brown soil zones as well as irrigated areas. It is adapted to a wide variety of soil textures, including sandy soils. Slender wheatgrass has fair tolerance to acidity. It has excellent tolerance to salinity (Table 14), similar to Russian wild ryegrass but less than tall wheatgrass. Slender wheatgrass is a good choice on saline sites that dry up over summer. Alkalinity tolerance of slender wheatgrass is very good.

Slender wheatgrass has good drought tolerance, requiring annual precipitation of about 350 mm (14 in.). It is less drought tolerant than crested and western wheatgrass. Slender wheatgrass seedlings can withstand some flooding. Established stands have excellent flood tolerance in early spring but less during the growing season. It grows well on sites that flood in the spring and become drier by summer, such as flood plains and around sloughs. It has fair tolerance of soil with poor internal moisture drainage. It is adapted to high elevations.

LIMITATIONS

The greatest limitation of slender wheatgrass is its short longevity. The productive life of a stand is three to five years depending on growing conditions. It is fairly drought tolerant but not enough for the drier parts of the Brown soil zone.

HAY AND SILAGE

Slender wheatgrass is lodging resistance, easy to harvest and is well suited to hay and silage production. It should be cut soon after heading for good quality. Palatability of early cut hay is good.

PASTURE

Slender wheatgrass yields much less for pasture than for hay and has only fair tolerance to grazing. As it is short lived, close, frequent grazing needs to be avoided to maintain good productivity.

Rotational grazing enables a relatively small area to be grazed quickly and evenly and enables better utilization if palatability is a factor. Slender wheatgrass should be grazed before stems elongate. Continuous grazing mixed stands may result in initial growth being avoided or the regrowth grazed too closely.

Slender wheatgrass palatability is fair although it heads early, becoming stemmy and coarse. In mixtures with more palatable species, such as Russian wild ryegrass or alfalfa, it may be avoided. It is acceptable to livestock depending on stage of maturity and absence of more palatable species.

On native rangeland, slender wheatgrass is a decreaser species on the Western Wheatgrass type rangeland, often found on clay soils that flood in spring, in southern Alberta. In the Aspen Parkland type rangeland, it is an increaser species (see Glossary).

Tall Wheatgrass

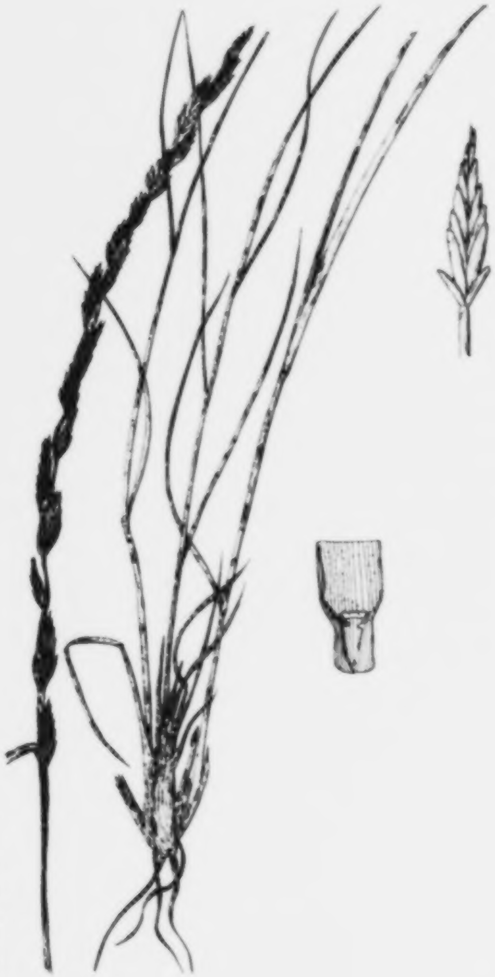
INTRODUCTION

Tall wheatgrass, *Elytrigia elongata* (Host) Nevski, is a perennial bunchgrass, native to southeastern Europe and Turkey. Early introductions into Canada were from southern Russia. It is closely related to intermediate wheatgrass.

Use in Alberta

Tall wheatgrass is a minor but important forage crop in Alberta. It has excellent tolerance to strongly saline soils that are moist or flooded for several weeks in spring. It is also tolerant of alkali conditions. It is adapted to Dark Brown and Black soil regions and to irrigated areas and is used for hay and pasture.

FIGURE 35
Tall wheatgrass



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DESCRIPTION

Tall wheatgrass is coarse, with stiff stems up to about 180 cm (6 ft.) in height. It has long, coarse basal leaves and stem leaves. Leaf sheaths are split with overlapping margins. Leaf blades are long, up to about 9 mm wide, loosely rolled, fairly erect, stiff and pale green. They are distinctly ribbed on the upper surface and rough on the underside. There are small auricles, often missing on older leaves, and short ligules.

Tall wheatgrass has deep, fibrous roots that can penetrate 3 m (10 ft.) or more into the soil, but are usually less deep. It is considered to be a bunchgrass, with plants increasing in size with age.

The head is a stiff, narrow spike to about 30 cm (12 in.) or more in length. There is a long space between spikelets with a gap or slight overlap between the top of one spikelet and the beginning of another. Spikelets have 5 to 11 flowers, which are cross-pollinated. There are no awns. Seeds are large and do not shatter easily.

GROWTH AND DEVELOPMENT

Seedlings develop slowly, have only fair vigour and competitive ability but establish fairly well if competition from other plants is minimized. Tall wheatgrass will establish in one season with good moisture but requires two years or more under dry conditions.

Tall wheatgrass begins growth in early spring but develops slowly and is very late flowering and maturing compared to other wheatgrasses grown in Alberta. Regrowth ability is poor.

Tall wheatgrass has good competitive ability once it is established. Late maturity and tall growth make it less suitable for mixtures than most forages. It can be seeded with other forages that tolerate salinity, such as slender wheatgrass. It grows well alone and may be seeded as a pure stand, especially on moist saline sites.

Tall wheatgrass is vigorous and has good winter hardiness, but not as much as some other grasses (see Table 10). It has good longevity under good growing conditions but is short lived under very dry conditions.

YIELD AND QUALITY

Tall wheatgrass is high yielding, especially when nitrogen levels are good. Feeding quality is good in the vegetative and early heading stages. Being very late in maturity, it maintains quality later in the season than most grasses, but it becomes very coarse and low in quality in later maturity stages.

ADAPTATION

Tall wheatgrass is adapted to the Dark Brown and Black soil regions and irrigated areas. It grows poorly on organic soil but grows well on clay, silt and sandy soils, although sandy soils are more likely to be moisture limiting. Tall wheatgrass has poor tolerance to acidity. It has excellent tolerance to salinity, tolerating strongly saline soils (EC of 8 to 16 dS/m) and alkalinity. It is most notable for its ability to grow well on saline and alkaline soils that are poorly drained. Growth is not affected by medium levels of salinity, and it will tolerate severely saline soils although yields will be reduced (see Table 14).

Tall wheatgrass has fairly good drought tolerance, although it does not persist well under very dry conditions. It has excellent tolerance to flooding, withstanding several weeks of spring flooding and short-term flooding during the growing season. It has very good tolerance to excess soil moisture in the root zone.

LIMITATIONS

Tall wheatgrass is not well adapted to sites that are both high in salinity and extremely dry.

Palatability is lower than many other grasses, especially when it is mature as it becomes very coarse.

HAY AND SILAGE

Tall wheatgrass yields well and can be hayed or ensiled. It is late maturing but becomes very coarse at later stages of maturity even though it stays green quite late in the season and should be harvested before or soon after heading. It stands erect and is easy to harvest for hay or silage. It should be cut leaving a high stubble.

PASTURE

Tall wheatgrass yields well, but regrowth is slow. It has fair tolerance to grazing but should not be grazed until it is well established. Initial spring grazing should be before stem elongation, leaving a minimum of 15 cm (6 in.)) of leafy residual material. Tall wheatgrass is best grazed rotationally to control height and frequency of grazing. Leaves are fairly frost tolerant.

Palatability of tall wheatgrass is good in the vegetative stage, but it becomes less palatable as it matures. Stems are avoided by livestock. Grazing animals may select against it in mixtures. Animal gains are good provided it is not too mature and intake is adequate.

TABLE 14
Yield of grasses grown under irrigation in low and high salinity soils

	Dry Matter Yield (t/ha) 1991 – 1993			
Species	**Salinity Tolerant**	**Low Salinity < 3.0 dS/m**	**High Salinity > 7.5 dS/m**	**% Reduction Due to Salinity**
Tall Wheatgrass	Yes	11.7	12.6	nil
Dahurian Wildrye	Yes	11.8	10.8	8
Russian Wildrye	Yes	9.4	10.4	nil
Smooth Brome	Partially	12.6	9.8	22
Tall Fescue	Partially	12.6	9.6	24
Crested Wheatgrass	Partially	10.3	9.2	11
Slender Wheatgrass	Yes	11.1	9.0	19
Altai Wildrye	Yes	4.6	6.8	nil
Orchardgrass	No	11.8	6.6	44
Timothy	No	11.5	5.4	53

Adapted in part from McKenzie and Najda 1993 (Millicent, Alberta)

Note: dS/m is deciSiemens per meter. It is a measure of the electrical conductivity of a solution and is used to determine the salinity of soil.

The high salinity level in this trial ranged from approx. 9.0 to 10.7 dS/m i.e. just into the strongly saline range of 8 to 16 dS/m.

Western Wheatgrass

INTRODUCTION

Western wheatgrass (*Pascopyrum smithii* (Rydb.) Love) is a long-lived, rhizomatous perennial sod forming grass that is native to Alberta and occurs across much of the Canadian prairies, into Ontario and the Northern Great Plains of the United States. In Alberta, native western wheatgrass is a constituent of the mixed prairie on Brown and Dark Brown soils, including saline sites. It is also found on fescue prairie on the Black soils and grasslands of the south exposed Peace River slopes. It is a common native species in the dry interiors of the western United States where it is also known as bluejoint and also as bluestem.

WESTERN WHEATGRASS PLANT

Western wheatgrass is very variable, and specific traits can be selected from the native prairie grasslands. Walsh, a Canadian variety, was developed from native plants collected throughout the plains region of Alberta and Saskatchewan.

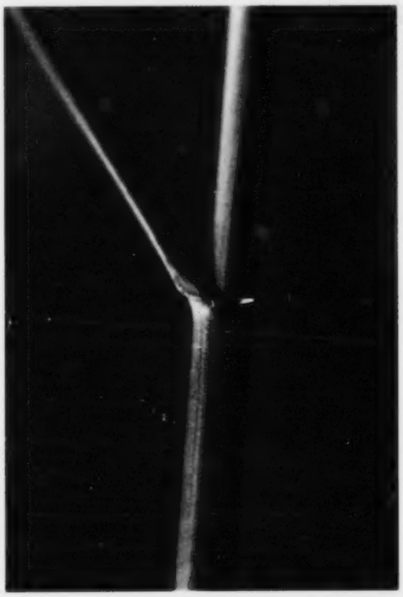
Western wheatgrass is very similar in appearance to northern wheatgrass and can be differentiated by its blue-green foliage, leaves that are at about a 45-degree angle relative to the stem, auricles that are often purple at the base and glumes that are rigid and similar in length to the lemmas.

Use in Alberta

Western wheatgrass is adapted to the Brown, Dark Brown, Black and Gray Wooded soil regions, is hardy, drought tolerant and salinity tolerant. It is often seeded on clay soils that flood periodically and where native forage is desired. Western wheatgrass establishes slowly from seed, but stabilizes soil well once rhizomes develop. It is used for reclamation as well as pasture and hay, although yields are modest.

DESCRIPTION

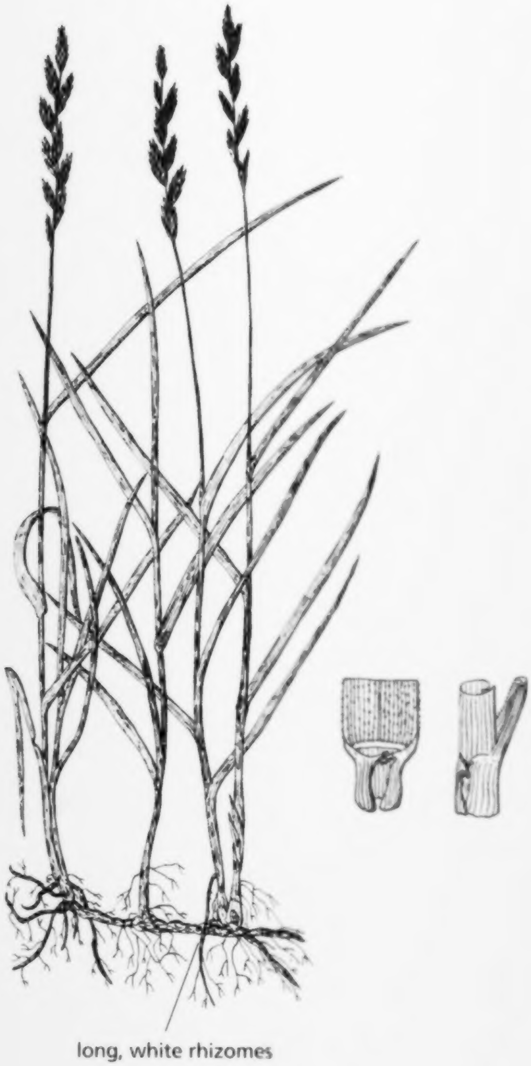
Stems are erect to 60 cm (24 in.) or more in height. Leaf sheaths are open and often purplish at the base. Leaves are attached at about a 45-degree angle relative to the stem, stiff, flat or rolled inward, up to 6 mm wide, 20 to 30 cm (8 to 12 in.) long and have sharply pointed tips. The upper leaf surface has distinct, coarse veins while the underside is smooth. Leaf margins are rough. Stems and leaves are blue-green with a slightly waxy coating that can be rubbed off (i.e. glaucous). Auricles are small, claw-like and often purplish at the base. Ligules are very short (0.5 mm).



WESTERN WHEATGRASS LEAVES ARE ATTACHED AT ABOUT A 45 DEGREE ANGLE TO THE STEM

Western wheatgrass has a well developed root system with deep roots, penetrating to as much as 1.5 m (5 ft.). Rhizomes are long, white, aggressive and produce a uniform sod. Thin stands will thicken from rhizome extension, and plants tend to be separated from each other rather than bunched. Rhizome aggressiveness may vary between strains and varieties.

FIGURE 36
Western wheatgrass



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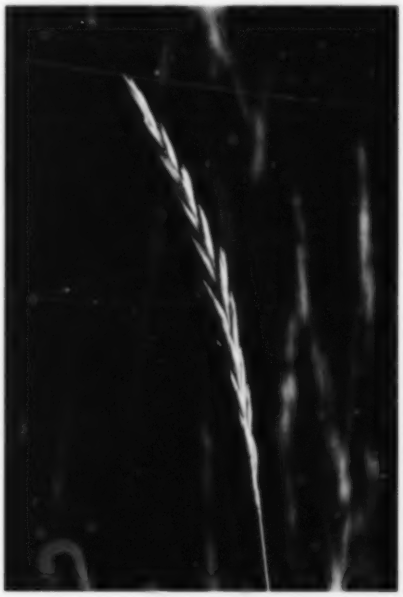
Seed heads (spikes) are slender, up to 15 cm (6 in.) long with 1 or sometimes 2 spikelets per node. Spikelets are up to 2 cm (3/4 in.) long, may overlap closely and have 6 to 10 flowers, which are cross-pollinated. Glumes are 10 to 12 mm long, rigid and taper to a very short awn tip. Lemmas appear similar to glumes and may have short awns. Seed is quite large, and a high percentage of dormancy is common.



WESTERN WHEATGRASS SEED HEAD

GROWTH AND DEVELOPMENT

Western wheatgrass seedlings have poor vigour and are slow to develop and establish. By the second or third year, rhizomes are vigorous, and the stand thickens from rhizome extension.

Western wheatgrass develops less quickly in spring than some introduced grasses such as crested wheatgrass and Russian wild ryegrass. It grows fairly well in midsummer and will continue to grow slowly during drought. It has fair regrowth ability.

Established western wheatgrass is rhizomatous and quite competitive in mixtures with other forages and perennial weeds. It has excellent hardiness, longevity and persistence. Hardiness is comparable with other very hardy grasses, such as crested wheatgrass and Russian wild ryegrass (see Table 10).

YIELD AND QUALITY

Western wheatgrass produces modest yields, generally less than introduced grasses (Table 13). It yields well on sites where it is most adapted, such as heavy clay soil that is flooded in spring.

Western wheatgrass is known for good quality, and it cures well on the stem, making it useful for dormant season grazing. Trials at Lacombe demonstrated that the quality of initial growth can be adequate for dry beef cattle maintenance in the fall, and regrowth can be adequate for beef cows with calves in the fall (see Table 15).

TABLE 15
Quality of initial spring growth stockpiled until harvest – Lacombe, Alberta, 1998 – 2000

	Total Digestible Nutrients (%)			Protein (%)			
Harvest Date	**Sept 15**	**Oct 15**	**Apr 15[1]**	**Sept 15**	**Oct 15**	**Apr 15[1]**	**Yield[2] (kg/ha)**
Western Wheatgrass	59.5	58.6	56.4	9.7	7.4	5.2	7,540
Meadow Bromegrass	57.7	56.9	56.1	10.0	8.8	7.4	8,610
Alfalfa	55.4	54.5	48.2	11.8	10.9	10.4	7,350

Quality of regrowth after cutting July 1 and stockpiled until harvest – Lacombe, Alberta, 1998 – 2000

	Total Digestible Nutrients (%)			Protein (%)			
Harvest Date	**Sept 15**	**Oct 15**	**Apr 15[1]**	**Sept 15**	**Oct 15**	**Apr 15[1]**	**Yield[2] (kg/ha)**
Western Wheatgrass	62.0	61.6	57.9	16.4	11.2	6.6	3,450
Meadow Bromegrass	60.1	64.0	57.0	9.6	5.1	6.5	4,490
Alfalfa	60.0	57.2	48.7	12.3	10.0	3.5	3,560

[1] April 15 harvest date is for stockpiled growth from the previous year, after wintering in the field

[2] Yield is the average of the three harvest dates over the three years of the trial

Adapted from Baron et al 2002

ADAPTATION

Western wheatgrass is adapted to the Brown, Dark Brown Black and Gray Wooded soil zones of Alberta. It is most adapted to heavy clay soils, especially those that flood in the spring. It grows well on deep clay and silty soils that are well to moderately well drained. It is less adapted to sandy soils and excessively drained sites. Western wheatgrass has fair tolerance of acidity. It has excellent salinity tolerance, although less than tall wheatgrass, and grows well on fine textured, poorly drained saline sites. It has very good alkalinity tolerance.

Western wheatgrass has excellent drought tolerance and continues to grow during drought but yields poorly. It needs more moisture to be productive than some grasses. Established stands have excellent tolerance to spring flooding and periodic flooding during the growing season. It has good tolerance to excess soil moisture in the root zone and will grow through silt that has been deposited during flooding of streams.

Western wheatgrass is a very hardy, flood and drought tolerant native species with strong sod characteristics, making it useful for preventing soil erosion. It is useful for re-vegetating depleted rangeland, on oil leases, pipelines, grassed waterways, etc.

LIMITATIONS

Very slow stand establishment and modest yield are the most limiting aspects of western wheatgrass.

HAY AND SILAGE

Western wheatgrass is known among native grasses as making good hay, and ranchers often used it for horse feed in the early settlement years. The hay is leafy, and quality and palatability are excellent if the forage is put up early and in good condition.

Western wheatgrass should be harvested by the early heading stage as quality declines with advancing maturity. It grows erect and is generally easy to harvest for hay and silage.

PASTURE

Western wheatgrass is well suited to grazing and yields relatively better for pasture than for hay. Young stands tend to form seed heads much more than older stands. Western wheatgrass has good tolerance to grazing provided it is not grazed too close or too frequently. Being rhizomatous, it is resistant to animal treading.

Rotational grazing is advantageous for western wheatgrass since it should be grazed later in spring than most introduced grasses. It is less palatable than some species and may be avoided by livestock, especially with continuous grazing, which may allow it to dominate mixed stands. Rotational grazing enables even grazing without grazing too close. A 10 cm (4 in.) height of residue should be left, as close grazing is detrimental to the stand. Leaves cure well for dormant season grazing.

Native western wheatgrass is a decreaser species in the mixed prairie of the Brown and Dark Brown soil zones. Decreaser species are well liked by livestock and are the first to decrease in abundance if grazing is too heavy. It is an increaser where present on fescue prairie of the Black soil zones. Increaser species increase under normal grazing pressure but decrease if grazing pressure is heavy on an ongoing basis.

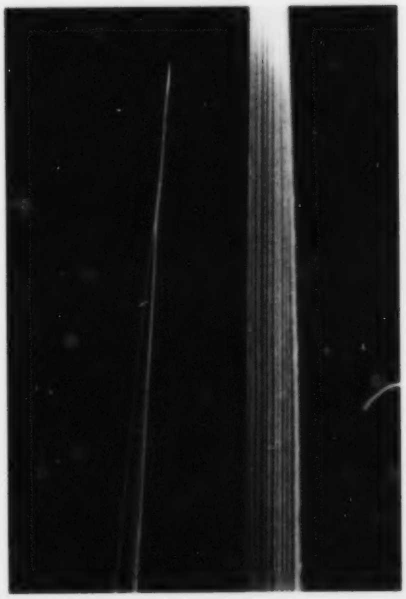
Altai Wildrye

INTRODUCTION

Altai wildrye (*Leymus angustus* (Trin.) Pilger) is a long-lived grass that is native to western Siberia, Mongolia and Kazakhstan. The first variety, Prairieland, was licensed in 1976, having been developed in Swift Current from seed originating from the Altai mountain region of Siberia and Mongolia.

ALTAI WILDRYE PLANTS

ALTAI WILDRYE GRASS LEAVES



ALTAI WILDRYE LEAF DETAIL

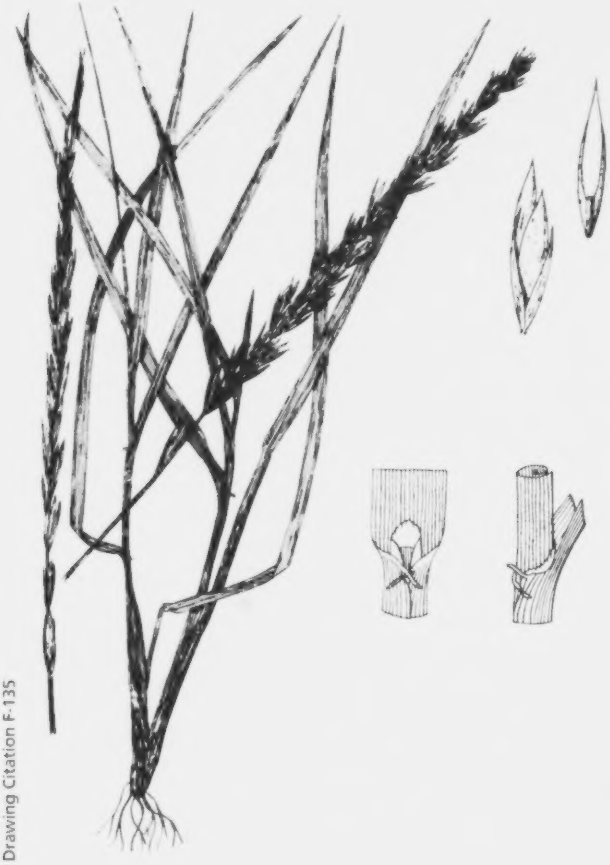
Use in Alberta
In Alberta, Altai wildrye is adapted to the Brown and Dark Brown soil regions. It is well suited for summer and fall pasture. It is slow to establish, produces modest yields, but is drought and saline tolerant and has a long growing season.

DESCRIPTION

Altai wildrye stems are up to 120 cm (4 ft.) in height, and leaves are mainly basal. Leaf sheaths are smooth, open and prominently veined. Leaf blades are very long, mainly erect, up to 12 mm wide, thick, stiff, flat and prominently veined with rough margins. Leaves are green or blue-green (glaucous) with varieties differing in colour proportions. Auricles are clasping, overlapping, and ligules are short, less than 2 mm long, and somewhat pointed.

Altai wildrye is noted for its extensive, deep roots that can penetrate soils to depths of 3 to 4 m (13 ft.), and it can obtain moisture from a high water table. It has very short rhizomes, but plants mainly form large tufts or bunches.

FIGURE 37
Altai wildrye



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Seed heads (spikes) are long (10 to 20 cm (4 - 8 in.)) and thick, with two or more spikelets per node. Spikelets have thin glumes that are 10 to 18 mm long with 2 to 4 or more flowers. Seeds are large, and the lemmas are 10 to 20 mm long and taper to a short awn. Seeds tend to shatter, but not as easily as Russian wild ryegrass.

Compared to Russian wildrye, Altai wildrye plants are larger and more vigorous, leaves are wide and stiff, the seed head and spikelets are longer and seeds are about three times larger.

GROWTH AND DEVELOPMENT

There has been some variety selection for improved establishment, but Altai wildrye is still difficult and slow to establish, although not as slow as Russian wildrye. Altai wildrye seeds can emerge from deeper seeding but should be planted 2 to 2.5 cm (3/4 - 1 in.) deep. Seedlings lack vigour, develop and establish slowly and are not competitive with weeds or other crops during establishment. Altai wildrye is not very productive during the year after seeding but should reach full production by the third year after seeding.

Short-lived forages such as slender wheatgrass can be seeded with Altai wildrye to provide additional yield during establishment. These crops may increase yield in the short term, but the Altai wildrye may not recover from the competition in the long term.

Altai wildrye grows less quickly in early spring than some grasses but has low growing points and fair regrowth ability. It has a high leaf-to-stem ratio. Research by Willms (1986) showed that annual production of Altai wildrye was nearly doubled at Stavely, Alberta, when harvested in early summer and again in the dormant season compared to a single harvest after the growing season.

The competitive ability of Altai wildrye is not as great as some grasses, such as Russian wildrye or crested wheatgrass, but it generally grows well in mixtures. It is often grown alone or with alfalfa. Lack of competitive ability with weeds can be a problem.

ALTAI WILDRYE SEED HEAD

Altai Wildrye

Altai wildrye has excellent hardiness and longevity. It has excellent cold tolerance, within the ranges of smooth bromegrass and Russian wildrye (see Table 10).

YIELD AND QUALITY

Altai wildrye produces modest yields, considerably less than some introduced grasses, such as smooth bromegrass and crested wheatgrass, but generally somewhat more than Russian wildrye.

The quality of Altai wildrye is typical for a grass in early spring, but it maintains its quality fairly well. In fall, leaves cure on the plants, enabling fall and early winter grazing. Regrowth forage has higher quality in the dormant season than initial growth. Willms' study showed that in southern Alberta, regrowth from summer had 7.9 per cent crude protein in January compared to 6.2 per cent for the original growth.

ADAPTATION

Altai wildrye is adapted to the Brown and Dark Brown soil regions of Alberta. It does best on silt and clay soils, has fair tolerance to acidity and excellent tolerance of salinity (Table 14), although somewhat less than tall wheatgrass.

The drought tolerance of Altai wildrye is excellent, and it continues to grow slowly and maintain its colour during drought. It has fair flood tolerance in early spring but poor tolerance during the growing season. It has fair tolerance to excess moisture in the root zone.

LIMITATIONS

Altai wildrye is difficult and slow to establish and requires better establishment conditions than most grasses. It is particularly hard to establish on sandy soil in the drier areas of the province.

HAY AND SILAGE

Altai wildrye is poorly suited for hay and silage production as its basal leaves result in high leaf loss. The plants have a strong bunch growth, making for rough fields. Hay quality is good.

PASTURE

Altai wildrye is well suited to pasture production, has fair regrowth ability and provides a long season of use. It has low growing points and good grazing tolerance. It can be grazed in spring, summer or in the dormant season. It is suitable for continuous light grazing.

Rotational grazing enables better utilization where forages differ in palatability and is more able to utilize Altai wildrye to complement other pasture that may be available. For example, crested wheatgrass-based pasture could be grazed in early spring with Altai wildrye deferred until later. Extending the grazing season into fall and early winter is one of the best uses of Altai wildrye. Leaves cure well in the field, remain on the plants and the erect growth stands up after snowfall.

After grazing, a fairly high leafy residue (e.g. 15 cm or 6 in.) should be left.

Altai wildrye has good palatability but may be less palatable than some species early in the season. It retains acceptable palatability into fall, including after frost has occurred, despite being very coarse.

Dahurian Wildrye

INTRODUCTION

Dahurian wildrye, (*Elymus dahuricus* Turcz. ex Grieseb.) is native to Siberia, Mongolia and northern China (Lawrence et al. 1990). Canadian varieties to date have been of Chinese origin. Dahurian wildrye and slender wheatgrass have been reclassified to the same genus.

DAHURIAN WILDRYE PLANTS

Use in Alberta
Dahurian wildrye has limited use for hay and pasture in the Brown, Dark Brown, Black and Gray Wooded soil areas. It establishes quickly and easily but is not long lived.

DESCRIPTION

Stems are erect to 1 to 1.5 m (3 - 5 ft.) height, and leaf sheaths are very long, holding the leaves high on the stems. The sheaths are open and overlapping. Leaves are wide (up to 15 mm) with prominent veins. They have small, clasping auricles and a short ligule.

DAHURIAN WILDRYE LEAVES

Dahurian wildrye is shallow rooted. It is a bunchgrass and does not creep.

Spikes (heads) are up to 15 cm (6 in.) long with 2 to 4 spikelets per node. Each spikelet has three to five florets, which are self-pollinated. Seed is quite large with awns up to about 2 cm (3/4 in.) long.

GROWTH AND DEVELOPMENT

Dahurian wildrye has excellent seedling vigour, establishes quickly and is competitive with other plants, including establishing legumes. With favourable moisture, it heads out, yields well and can be utilized on the establishment year. Dahurian wildrye can establish and stabilize soil very quickly.

Spring growth of Dahurian wildrye begins early, and it has good regrowth ability, providing a better distribution of growth than most other dryland grasses. It is not as leafy as Russian or Altai wildrye.

Dahurian wildrye is very competitive and does well in short rotations.

The longevity of Dahurian wildrye is poor, with stands usually remaining productive for only two or three years. Winter hardiness is good, although stands may be injured during severe winters.

Dahurian Wildrye

YIELD AND QUALITY

Dahurian wildrye has good yield while it persists. Quality is average for grass. Quality of initial growth becomes low at the mature stage but does not drop off as quickly as some grasses, such as crested wheatgrass.

ADAPTATION

Dahurian wildrye is adapted to Brown, Dark Brown, Black and Gray Wooded soil zones in Alberta. It does best on clay soils, is satisfactory on sandy soils but is not adapted to peaty soils. Dahurian wildrye is thought to have fair tolerance to acidity. It has excellent tolerance to salinity (Table 14) and alkalinity.

The drought tolerance of Dahurian wildrye is good. It has fair tolerance to spring flooding and moisture in the root zone during the growing season. It does best on well-drained soil.

LIMITATIONS

Stand longevity is generally two to three years and is the most limiting feature of Dahurian wildrye. Palatability is low after heading.

HAY AND SILAGE

Dahurian wildrye is well suited to hay and silage production in short rotations where it provides good yield in the establishment year if growing conditions are favourable. It should be harvested soon after heading as palatability decreases when it is cut too mature. It is easy to harvest.

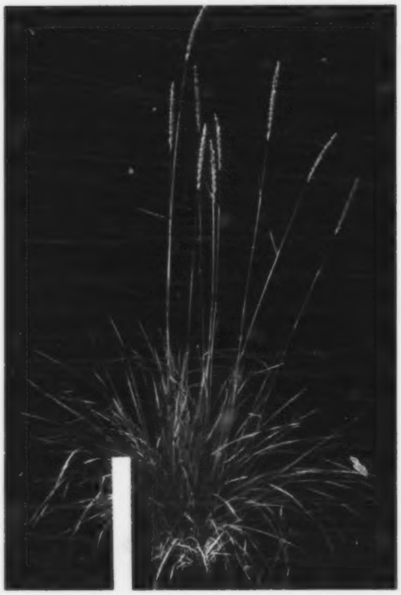
PASTURE

Dahurian wildrye begins growth early in spring and has a fairly good distribution of yield over the growing season, provided moisture is adequate. It has good tolerance to grazing. A rotational grazing system enables the best use of its good regrowth ability. Dahurian wildrye has good palatability in the vegetative stage, but it becomes unpalatable when stems develop.

Russian Wildrye

INTRODUCTION

Russian wildrye (*Psathyrostachys juncea* (Fisch.) Nevski) is an introduced perennial grass. It is native to parts of Russia, the Middle East and central and northern Asia, including Mongolia and northern China.



RUSSIAN WILDRYE PLANT

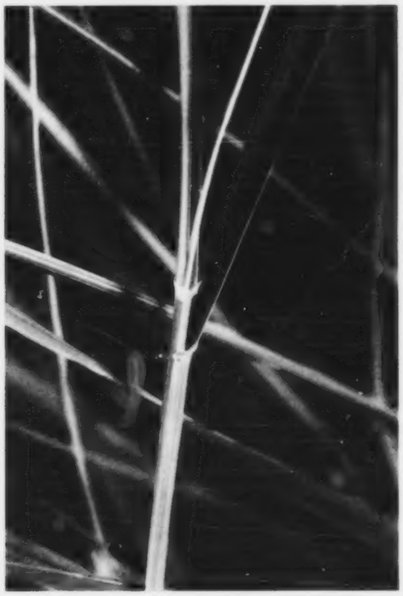
There are diploid and tetraploid types, both with similar adaptation. Tetraploids have larger leaves, heads and seeds but similar palatability and quality compared to diploid types.

Use in Alberta

Russian wildrye is a long-lived grass that is best adapted to the Brown and Dark Brown soil regions of Alberta. It is difficult to establish but is very cold tolerant and persistent once established. It produces modest yields but quality and palatability are good. Russian wildrye is mainly used as dryland pasture, often to extend the grazing season in the fall and winter months.

DESCRIPTION

Russian wildrye has erect stems to about 1 m (3 1/4 ft.) high or more. Leaf sheaths are smooth (hairless) and open at the top. It has an abundance of basal leaves that are up to 6 mm wide and 30 cm (12 in.) long, flat or rolled, prominently veined on the upper side and dull green or blue-green. Auricles are clasping, and the ligules are very short, up to about 1 mm long with a blunt tip.



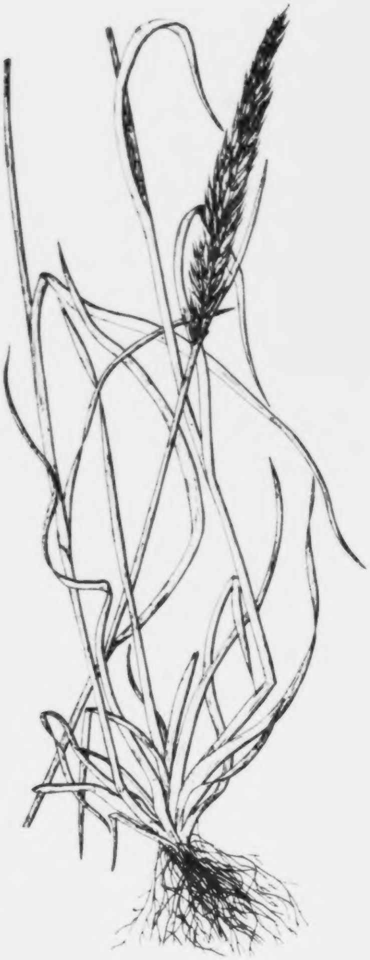
RUSSIAN WILDRYE LEAF

Russian wildrye has an abundance of wide spreading fibrous roots. It is deep rooted with some penetration to about 3 m (10 ft.) depth. There are no rhizomes. The bunch habit of growth results in rough fields or pastures.

The spike (head) is compact (dense) and about 5 to 12 cm (2 - 4 3/4 in.) long. There are two or three spikelets per node. Glumes are 4 to 5 mm long, much shorter than the spikelets which are 12 to 15 mm long. Spikelets overlap each other. Each spikelet has two to six flowers which are cross-pollinated, producing seeds that shatter easily. The lemmas are 5 to 7 mm long and are awn tipped.

Compared to Altai wildrye, Russian wildrye plants are smaller, the leaves are narrower and tend to droop, the seed head is shorter and the seeds are one third as large.

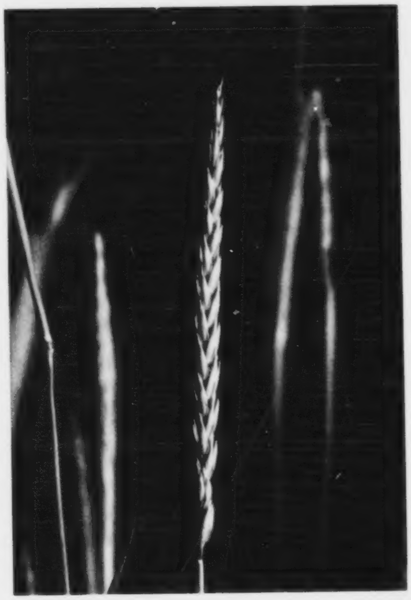
FIGURE 38
Russian wildrye



Drawing Citation F-141

GROWTH AND DEVELOPMENT

Russian wildrye seedlings are not able to emerge from deep seeding, have poor vigour and are very slow to establish. This forage is especially difficult to establish on sandy soils, which may dry out soon after seeding. Improvement of establishment has been a major breeding objective with recently released varieties having a greater ability to establish. Establishment is, however, still slow. Russian wildrye competes very poorly with nurse crops and weeds during establishment. It needs a least a full season or more to establish.



RUSSIAN WILDRYE SEED HEAD

Very wide row spacings (e.g. 90 cm (36 in.) spacing) were once recommended for Russian wildrye. Jefferson and Kielly found this approach maximized hay yield, as a greater proportion could be harvested, but did not necessarily improve pasture yield. Very wide row spaces increase soil erosion and result in very rough fields. A 30 cm (12 in.) row space is more satisfactory.

Including annuals, such as oats, or short-lived crops, such as slender wheatgrass, can provide more production in the initial years of a stand. This method tends to result in a trade-off of increased short-term yield with poorer long-term performance of Russian wildrye, but has advantages in weed suppression.

Russian wildrye begins growth fairly early in spring and develops more quickly than most native grasses, but not as fast as crested wheatgrass. It has low growing points and fair regrowth ability through until fall, giving it a good seasonal distribution of yield where moisture is sufficient. Russian wildrye has a very high leaf-to-stem ratio.

Once established, Russian wildrye is very competitive but not especially compatible in mixtures as it can crowd other species out of a stand. Mixtures with alfalfa are more productive than Russian wildrye alone although the alfalfa does not persist as long as the Russian wildrye. Seeding mixtures with the other species in crossed or alternate rows decreases the competition against Russian wildrye during the establishment period and protects the other species from competition after establishment.

Russian wildrye has excellent cold tolerance (see Table 10), making it very winter hardy, and it has excellent longevity.

YIELD AND QUALITY

Russian wildrye generally produces modest yields compared to most other introduced tame grasses. It yields relatively better as pasture than as hay (Table 12). Yield is closely related to soil moisture in the spring months, and productivity decreases in older stands. The productivity of an older stand can be improved by direct seeding alfalfa into the stand or by fertilizing with nitrogen.

In a study by Smoliak and Dormaar at Manyberries, Alberta, over a 25-year period, unfertilized Russian wildrye yielded 47 per cent more than native rangeland, and crested wheatgrass yielded 113 per cent more than native rangeland.

Russian wildrye has both good protein content and digestibility. Initial growth retains its quality better into fall and winter than most other grasses.

ADAPTATION

Russian wildrye is adapted to the Brown and Dark Brown soil regions of Alberta. It does best on silt and clay textured soils, especially fertile soils. It is very difficult to establish on sandy soils but grows well once established. Russian wildrye has only fair tolerance to acidity but excellent tolerance to salinity (see Table 14). There are some variety differences in salinity tolerance. It is alkaline tolerant.

Russian wildrye has excellent drought tolerance. It has poor tolerance to spring and summer flooding and only fair tolerance to excess moisture in its root zone.

LIMITATIONS

Slow establishment is the most limiting aspect of Russian wildrye. It is especially difficult to establish on sandy or gravely soils. Soil crusting and competition from weeds affect establishment. Newer varieties have improved establishment, but it is still the most important aspect of Russian wildrye management.

The extreme bunch growth habit leaves bare gaps between plants so that soil is vulnerable to erosion and fields are rough.

HAY AND SILAGE

Russian wildrye is poorly suited to hay and silage production as its extreme bunch habit of the growth makes for very rough fields and difficult cutting. Leaves are basal resulting in high leaf loss during hay harvesting. Hay is palatable, and quality is good, depending on stage of maturity.

PASTURE

Russian wildrye is very well suited for pasture production in the drier areas of Alberta and can be grazed anytime from early spring to early winter. Since it is lower yielding than most other tame grasses, it is best to limit the acreage of Russian wildrye and use it to complement other pasture species, such as extending the grazing season in fall and winter.

RUSSIAN WILDRYE IN SOUTHEASTERN ALBERTA

When it is well established, Russian wildrye has good tolerance to grazing. In dry areas, it can be grazed lightly in spring and again later in the season. It withstands early grazing better than native grasses, and a greater percentage of its annual yield can be utilized. It can be grazed down to about 8 to 10 cm (3 - 4 in.) in height. Continuous close grazing is detrimental.

Russian wildrye does well with continuous stocking, but rotational stocking utilizes it best. It can be grazed early in the season, deferring the use of native grasses to mid-season when they are more grazing tolerant. The initial growth of Russian wildrye maintains good quality for grazing in mid and late summer, complementing crested wheatgrass. It maintains better quality than other grasses in fall and winter and can be stockpiled to extend the grazing season. If grazed lightly in spring and then left to regrow, it provides high quality late season pasture

Russian wildrye has good palatability but is easiest to utilize in pure stands as livestock sometimes select other species in a mixture.

Leaves cure on the stem and maintain satisfactory palatability late in the season. Mature stems are unpalatable, cause eye irritation and are avoided by livestock.

ANNUAL FORAGES

Annual Forages

Annual forage crops can be used for winter feed, extending the grazing season and emergency or supplementary feed in Alberta. Annual crops can be cut and stored as greenfeed or silage for winter feed, or they can provide pasture in early spring, summer, fall or winter. They can be grazed during periods of drought, when perennial pasture production is low or when the perennials are dormant.

The main annual crops that have been used successfully for these purposes are oats, barley, fall rye, spring and winter wheat, spring and winter triticale, ryegrass (covered under the grasses section), corn, field peas, millets, sorghum, brassicas (turnips, kale, canola, rape and radish), fababean and Italian ryegrass. Many annual species have varieties that are forage types, e.g. forage oats.

Cereal Crops (Spring)

Cereal crops are well suited for livestock forage. The spring crops, barley, oats, triticale and wheat, are all excellent crops to grow for greenfeed, silage and swath grazing. They are productive, easy to grow, more economical than many other annuals and have good to excellent quality. They can be grazed although good management is needed to keep the crop vegetative and prevent the crop from heading out and going to seed.

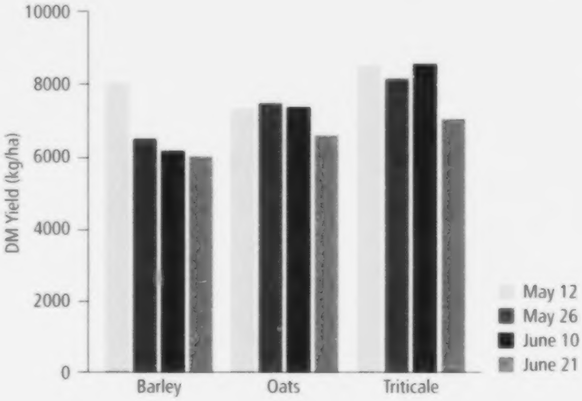
Oats are generally superior to other cereals in total yield for greenfeed, swath grazing and silage. Barley has the highest quality of all the cereals when used for stored feed (see Alberta Agriculture and Rural Development's *Silage Manual*, Agdex 120/52-2, for more information on growing cereals for silage).

For swath grazing, delay seeding cereals until early June to prevent them from maturing too early. Spoilage may occur if the cereals are swathed too early and left in the field. If seeded too late, yields will be reduced. Late seeding of barley can result in yield reductions of up to 25 per cent compared to early to mid-May seeding (Figure 39). This difference may be due to the early-seeded crop taking advantage of more abundant early spring moisture and/or being more advanced and therefore less susceptible to drought conditions that can occur in July and early August.

Oats and triticale (Figure 39) appear to be more tolerant of later seeding, with no significant yield loss up to the June 10 seeding date. Later seeding of oats produced only 90 per cent of the average dry matter yield of seeding dates between May 12 and June 10. Triticale seeded at this time yielded 84 per cent of that from earlier seeding dates.

BARLEY

FIGURE 39
Whole plant dry matter yield of spring barley, oat and triticale seeded at four dates at Lacombe, Alberta



OATS

Cereals Crops (Winter)

The winter cereals, fall rye, winter triticale and winter wheat, can be used for spring, summer or fall pasture. They are particularly valuable when seeded in late summer and overwintered for use in the spring when they grow much earlier than most perennials. They can be pastured from the time they are 15 cm (6 in.) high (about mid-May) until June 1 and still produce a grain crop if good moisture conditions prevail. Spring grazing delays crop maturity. Grazing can continue through the summer, although it is difficult to keep the crops vegetative.

Winter cereals for fall pasture should be planted August 1 to 15. Fall grazing should start when the crop has developed to the point where the ground is well covered. It should not be grazed so heavily that the ground is bare. Fall grazing reduces spring growth and grain yield.

Spring-seeded winter cereals produce a mass of leafy growth that is ideal for pasture in summer or fall. The leafy growth stays green until freeze-up and provides good grazing. Winter cereals must be vernalized (exposed to cold temperatures) before they will produce stems and seeds. This characteristic makes them ideal pasture crops during the year of seeding. Including 20 to 25 kg/ha (20 - 25 lbs/acre) of oats or barley seed when spring seeding provides grazing a week earlier. By the second grazing, the winter cereals will be well established and will be well utilized by the livestock, which will often leave the spring cereals ungrazed after they have headed out.

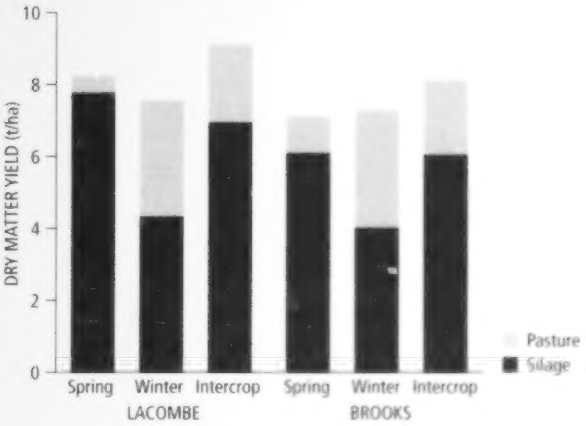
WINTER CEREALS FOR PASTURE

The winter cereals regrow well and are well suited to a rotational grazing system where they can be allowed to rest and recover for three to four weeks. They respond well to fertility, and yield can be influenced by the application of nitrogen fertilizers. Winter cereals produce and maintain their quality well into the fall, making them an ideal crop for use in fall when perennial pastures should be rested and for extending the grazing season into late fall.

Fall rye and winter triticale are better suited for grazing than winter wheat as they remain productive later in the fall. Fall rye is more winter hardy and should be used if the crop is needed for pasture the following spring.

Winter cereals can be intercropped (grown together) with spring cereals to provide greenfeed or silage and the regrowth utilized for fall pasture. To provide good silage or greenfeed yield and a good pasture yield, both crops should be seeded at three quarters of their normal seeding rates. Once the spring cereal has been harvested, the winter cereals should be allowed to regrow and can be grazed for fall pasture. There may be a slight reduction in silage or greenfeed yields (Figure 40), but total forage yield including regrowth used for pasture is higher in the intercrop system than when spring cereals are grown alone. With the leaf material from the winter cereal included in the silage or greenfeed, the quality of the forage is increased (Table 16).

FIGURE 40
Intercrop for silage and pasture at Lacombe, Alberta, and Brooks, Alberta



Spring – Spring Cereal
Winter – Winter Cereal
Intercrop – Spring Cereal and Winter Cereal

V. Baron et al, Lacombe Research Centre

TABLE 16
Quality of intercrop silage

Crop	Protein %	Digestibility %
Oats	10.2	58.0
Barley	10.6	64.3
Winter Cereal	19.5	74.7
Oats/Winter Cereal	14.0	62.8
Barley/Winter Cereal	12.8	66.8

V. Baron, Salmon, Najda and de St. Remy - Lacombe & Brooks, Alberta

WINTER CEREAL UNDERSEEDED INTO OATS

GRAZING WINTER CEREAL REGROWTH AFTER SILAGING A SPRING CEREAL/WINTER CEREAL INTERCROP

Winter cereals are generally high in protein and low in fiber. Access to straw, fed free choice while grazing winter cereals, will provide additional fiber, which may be necessary.

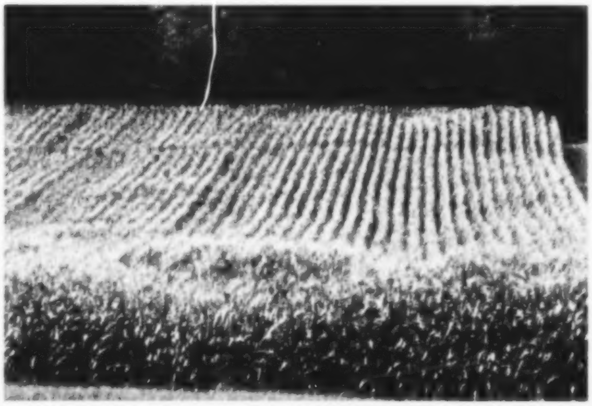
A danger with winter cereal pastures is grass tetany (grass staggers), which results in muscle stiffness and loss of coordination in grazing animals. This is associated with lush-growing forages on land that has been heavily cropped or heavily fertilized. Feeding livestock a mineral mix containing magnesium may be necessary to overcome this problem.

Corn

Corn has the highest potential yield of all silage crops in the traditional corn growing areas of southern Alberta. It can also be used to extend the grazing season in other areas of the province. Corn yields are relative to the amount of corn heat units received in the areas they are grown (Figure 41). In areas below a minimum of 2100 corn heat units, corn yields are very inconsistent from year to year, and generally, corn will not out yield spring cereals for silage (Table 17 and Table 18). Corn is a higher risk and a more expensive crop to grow for winter feed than cereals.

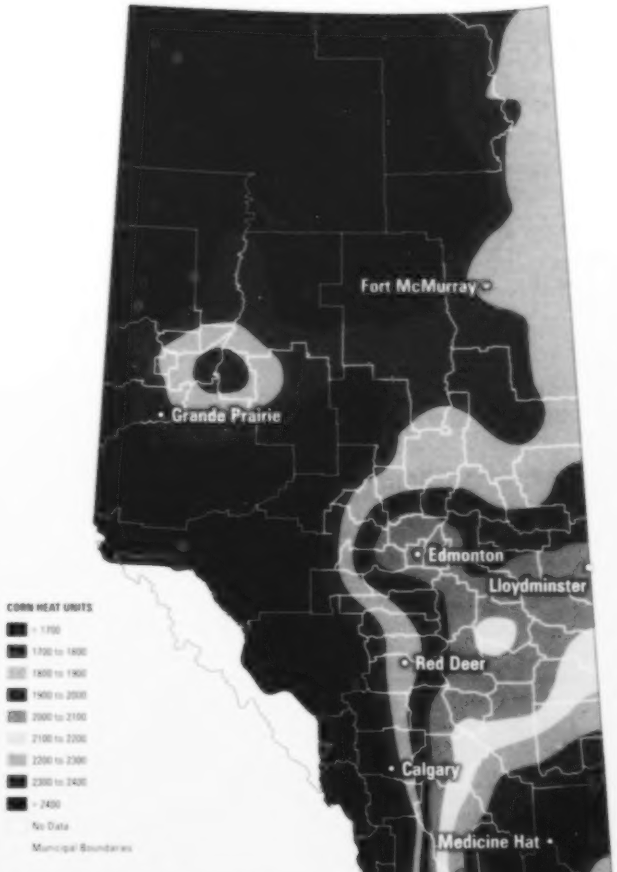
Corn has potential for fall and winter grazing to extend the grazing season. Corn grows during the full growing season in non-traditional corn growing areas, whereas crops such as cereals, which are sometimes seeded later in the spring to delay maturity or spread out a harvest season, do not. This delay reduces the yields of cereals used for swath grazing (Figure 39). Corn stands up well through snow, although it should be strip grazed to reduce selective grazing and trampling.

For more information on growing corn, see the *Silage Manual*, Agdex 120/52-2.



CORN

FIGURE 41
Average number of corn heat units received


Fort McMurray
Grande Prairie
Edmonton
Lloydminster
Red Deer
Calgary
Medicine Hat
Lethbridge
CORN HEAT UNITS
< 1700
1700 to 1800
1800 to 1900
1900 to 2000
2000 to 2100
2100 to 2200
2200 to 2300
2300 to 2400
> 2400
No Data
Municipal Boundaries

Based on 1971 to 2000 data from Environment Canada, Alberta Environment and the U.S. National Climate Data Centre. Map displayed on Township generalization.

TABLE 17
Silage dry matter yield, per cent dry matter (DM) and ear of whole plant for four corn, one triticale, two semi-dwarf barley and one oat varieties at Bow Island, Brooks and Lacombe, Alberta (2001 & 2002)

	Bow Island			Brooks			Lacombe		
Crop	Yield t/ha	DM %	Ear %	Yield t/ha	DM %	Ear %	Yield t/ha	DM %	Ear %
Corn[1]	14.9	37	53	13.2	31	44	9.0	21	26
Triticale	5.5	32	–	6.4	35	–	6.9	36	–
Barley[1]	6.9	36	–	8.2	36	–	6.0	31	–
Oat[1]	7.1	27	–	7.1	28	–	9.0	29	–

[1] Corn (average of 4 varieties), barley (average of 2 semi-dwarf varieties), triticale (1 variety), oat (1 variety)

Corn hybrids ranged from 2,000 to 2,400 corn heat unit rating. Long-term average corn heat units (CHU) from planting until harvest are Bow Island – 2,514, Brooks – 2,354 and Lacombe – 1,860. Brooks and Bow Island locations were irrigated.

TABLE 18
Silage yield during wet and dry years at Lacombe, Alberta

	Dry Matter Yield (kg/ha)				
Crop	4 Year Average	1999	2000	2002	2003
Corn	8,853	6,724	7,620	9,413	11,655
Barley	7,788	8,069	8,965	4,034	10,086
Triticale	9,806	11,879	13,223	3,586	10,534
Oat	10,870	13,448	11,655	6,051	12,327
Rain (mm)	270	378	398	161	181
CHU	1,922	1,784	1,949	1,827	2,127

Barley – semi-dwarf variety

CHU – corn heat units

V.S. Baron – Lacombe Research Centre

Forage Brassicas

Forage brassicas include crops such as turnips, kale and forage rape, which all belong to the brassica family and can be used for pasture. They have been used in Europe for many years as fast growing and high quality pasture. Brassicas are adapted to the Brown, Black and Gray Wooded soil areas of Alberta but require sufficient amounts of rainfall to be productive.

The moisture content of most brassicas is very high, 85 to 90 per cent, which makes them very difficult to utilize as hay or silage. Brassicas are cold tolerant and are able to withstand freezing temperatures to -5° C, which makes them well adapted for fall grazing. They have fair acid tolerance, down to pH of 5.5 to 6.5, but they will not tolerate waterlogged soils. These crops are succulent and leafy with erect growth and should be strip grazed to reduce wastage from trampling as well as to manage them for better regrowth. Brassicas are low in fiber and high in digestibility, protein and moisture. Access to dry roughage such as hay or straw may reduce rumen disorders and increase animal performance.

These crops may also cause some health issues in livestock. When cattle are grazing forage brassicas, they should be monitored for potential health problems. Brassicas contain an amino acid compound, S-methylcysteine Sulphoxide (SMCO), which accumulates in the plants and can cause haemolytic anaemia in grazing livestock. SMCO levels increase as the crop matures. Even low levels of SMCO in the crop will generally cause poor growth rates and unthrifty animals. When high levels are present, livestock death may occur.

Early signs of haemolytic anaemia include loss of appetite, weakness, a fall in milk production, jaundice and excessive scouring (although animals grazing low fiber diets normally scour). Affected animals should be removed from the pasture. Prolonged grazing of brassicas should be avoided. When brassica feeding is stopped, the hemoglobin levels will return to normal in three to four weeks.

These crops also have glucosinolates, which can affect the thyroid uptake of iodine. Providing supplemental iodine should be considered when grazing brassicas. The calcium phosphorous (Ca:P) ratios in forage brassicas exceed the desired range, and corrective mineral supplements should be fed. Bloat and nitrate poisoning may also occur.

TURNIPS (*Brassica rapa* L.)

Many different types and varieties of turnips can be used for pasture. Varieties differ in the size and shape of the roots although more bulbous roots that grow exposed above the soil surface are generally preferred for grazing as they are easier for livestock to access. The tops can be grazed lightly once in mid to late summer, allowed to regrow and grazed again in the fall. The first grazing should be light to prevent livestock from grazing the roots, which will reduce regrowth and if grazed too close, may kill the plant. The livestock will graze the tops and the roots in the fall. The amount of roots available to graze in the fall varies from 15 to 55 per cent of the total plant, depending on the variety and growing conditions.

TURNIP

TURNIP TUBERS CAN BE GRAZED

KALE (*Brassica oleracea* L.)

Many types of kale can be used for forage including stemless kale, marrow stem kale, thousand-headed kale and hybrid types. The stemless types reach a height of 65 cm (25 in.) and mature early, which allows for a period of regrowth and a second grazing. The marrow stem types require a longer growing season but can grow to a height of 125 cm (4 ft.). They are high yielding but have a high ratio of stems, which are very digestible only in the immature stages. The stem of the marrow stem types may become very thick, but a higher seeding density may keep the stem thickness smaller and increase the leaf-to-stem ratio. Marrow stem types are most often grown for fall grazing in Alberta.

KALE

RAPE (*Brassica napus* L.)

The most common type of forage rape is the giant type, which is upright with larger stems, taller, leafier and higher yielding than the dwarf type, which is more branched and shorter. Forage rapes are not to be confused with canola or oilseed rape. Rape can be grazed eight weeks after seeding and allowed to regrow for a second grazing in the fall, or it can be grazed once in the fall. If an early grazing is planned, sufficient leaf material should be left to encourage quicker regrowth.

Millets

Millets are one of the oldest crops grown throughout history in dryland areas of Asia, Africa and the Middle East. They have generally been grown for seed but have also been used for forage. In Alberta, these crops are most often grown for forage or birdseed. The most common species grown for forage in Alberta are foxtail millet (*Setaria italica* (L.) P. Beauv.) and proso millet (*Panicum miliaceum* L.).

Millets are adapted to many soil and climatic conditions and can successfully be grown under dry conditions on marginal soils. Areas 1 and 2 are most suited to growing millets for forage. Under high moisture and high fertility, they are generally a poor choice since they do not produce as well as other crops in these growing conditions. Millets have a lower water requirement than most cereals and utilize water more efficiently than most crops.

Millets have a short growing season and generally can be harvested for forage in 70 to 90 days, depending on the species grown. Millets are shallow rooted making them easily uprooted, and regrowth after cutting is generally low, which makes them more suited as a hay crop than a pasture crop. When harvested for hay, millets should be cut in the late boot to early bloom stage. Millets need warm soils to germinate and do not tolerate frosts. The short season and need for warm soils make them ideal for June seeding. They are poor weed competitors, and weeds must be controlled the first few weeks after seeding or stand establishment will be poor.

Since millets are generally grown during droughty conditions, nitrates can be a problem. The glucoside setarian occurs in some cultivars, and when fed to horses in large quantities, it may cause complications such as kidney problems.

FOXTAIL MILLET (*Setaria italica* (L.) P. Beauv.)

Foxtail millet is the most common millet grown for forage in Alberta and tends to out yield proso millets. It is a leafy plant with slender, erect stems and can reach a height of 50 to 150 cm (20 - 60 in.). The seed head becomes very bristly as it matures and may cause sore mouths, lump jaw or eye infections when fed.

GOLDEN GERMAN MILLET

There are different types of foxtail millets. Common millet is the most used and is fine stemmed, leafy and early maturing. Siberian millet has medium-sized stems and is medium maturing. Hungarian millet has medium-sized stems, tends to do better under better moisture conditions and is early maturing. German millet has thicker stems and broader leaves and is later maturing.

PROSO MILLET (*Panicum miliaceum* L.)

Proso millet has a large coarse stem, is less leafy than foxtail millet and grows to 50 to 150 cm (20 - 60 in.) in height. The leaf blades are more or less hairy on both surfaces and the edges. The seed heads (panicles) are large, lax (droopy) and open headed. Proso millet is generally grown for birdseed but can be cut for hay. Hay yields of proso millet are generally lower than foxtail millets in Alberta.

PROSO MILLET

Sorghum

Sorghum (*Sorghum bicolor* L. Moench) and Sudangrass (*Sorghum bicolor* (L.) Moench ssp. *drummondii* (Nees ex Steud.) de Wet & Harlan) and sorghum x sudangrass hybrids are warm-season (C4) crops that can be used for hay, silage or pasture (see Glossary for cool-season (C3) and warm-season (C4) plants). They are adapted to the irrigated areas of Alberta but can be grown in area 1 where sufficient corn heat units (CHU) and moisture are available. With sufficient CHU, sorghum and sudangrass tolerate drought and growing conditions not suitable for growing corn. These crops grow best in warm fertile soils under irrigation but grow poorly under cool conditions and wet soils. Sorghum tolerates drought and heat stress due to a waxy covering over the leaf blades and sheaths, which reduces water loss.

Sorghum and sudangrass require warm soils (18 °C - 20 °C) for good establishment, and weed control during this period is critical. They do not tolerate acid or highly saline soils. Optimum pH is 6.2 to 7.8. Sorghums respond to high rates of fertility if moisture is available, although under droughty conditions, excessive nitrogen fertility may increase the nitrates in the forage to levels that cause nitrate poisoning in livestock.

Prussic acid poisoning, also know as hydrocyanic acid poisoning or cyanide poisoning, can occur when sorghum, sudangrass or sorghum sudangrass hybrids are consumed by livestock. These crops contain the cyanogenic glycoside called dhurrin which releases hydrogen cyanide (HCN) when the crop is eaten and digested. Cyanide is absorbed into the bloodstream. Cattle, sheep and other ruminants are more susceptible than horses. Microbes in the rumen may increase the release of HCN. Cyanide can affect livestock very quickly if the levels are high. Death can occur by asphyxiation within 30 minutes. Symptoms of prussic acid or cyanide poisoning include rapid breathing followed by slow labored breathing, muscle spasms and dilated pupils.

Prussic acid poisoning can occur when these crops are grazed at less than 60 cm (2 ft.) in height, when the crop is young and succulent. Plant stresses, such as frost, drought, injury from hail and high rates of nitrogen fertilizer can increase the levels of dhurrin in the plants. Grazing should be delayed for one to two weeks after a frost. As the plants mature, the level of dhurrin declines rapidly in the plant. When the forage is harvested and stored as silage, the level of dhurrin is reduced as the HCN is released as a gas after one or two months.

SORGHUM

Forage sorghum is similar to corn in that it has coarse thick solid stalks with few tillers and broad leaves. The leaves are shorter than corn and have saw-toothed margins. Sorghum can reach a height of 1.2 to 4 m (4 -13 ft.) under good growing conditions and is late maturing. The sorghum inflorescence is a loose to dense panicle having many branches on a hairy axis. Forage sorghum is generally harvested as silage and has a feeding value 85 to 90 per cent of corn silage. The coarse juicy stem makes sorghum difficult to harvest for hay as it is slow to dry for safe storage. Sorghums can be grazed after reaching a height of at least 60 cm (2 ft.) to reduce the potential for prussic acid poisoning.

SUDANGRASS

Sudangrass is fine stemmed, with many basal tillers and narrow leaves. It grows from 1.5 to 2.5 m (5 - 8 ft.) tall and has good regrowth. It is grown for hay and pasture. Forage yields are generally less than sorghum or sorghum x sudangrass hybrids. The finer stems and leaves allow it to dry much easier than forage sorghums, but drying for hay is slow. When cut for hay, it should be cut when the heads first appear as the palatability and quality is reduced when cut later. The main use of sudangrass is for grazing. Pastures should be divided into paddocks and grazed in a rotation so that each paddock is rested for about four weeks between grazings. It should not be grazed until the plants are about 60 cm (2 ft.) high as nitrates and prussic acid can be a problem.

SORGHUM X SUDANGRASS HYBRIDS

Many sorghum and sudangrass hybrids and crosses are used for forage. The hybrid plants are as tall as sorghum with an intermediate-sized stem and leaf with more tillers than sorghum but generally fewer than sudangrass. Yield, growth habit and prussic acid content differ widely between hybrids. The larger stems and taller growth habit of the hybrids make them best suited as silage. Sorghum x sudangrass can be grazed after it is at least 60 cm (2 ft.) in height to reduce the risk for prussic acid poisoning.

SORGHUM SUDANGRASS

Annual Legumes

Many other crops are grown for winter feed and pastures. Some are perennials in areas where they are better adapted, but with the climate and winterkill in Alberta, they are grown and harvested as annuals. Many are crops traditionally grown for seed but are used as annuals to sustain livestock during periods of dry weather.

FIELD PEAS

Field peas are grown for silage, greenfeed and swath grazing but are not used for pasture. This legume crop will produce a high protein and high energy silage. Varieties have been developed for forage (see the *Silage Manual*, Agdex 120/52-2, for more information).

FIELD PEA

FABABEANS

Fababeans can be used for silage but are not used for pasture. Fababeans are a long-season legume crop that will produce high protein silage (see the *Silage Manual*, Agdex 120/52-2 for more information)

FABABEAN

FENUGREEK

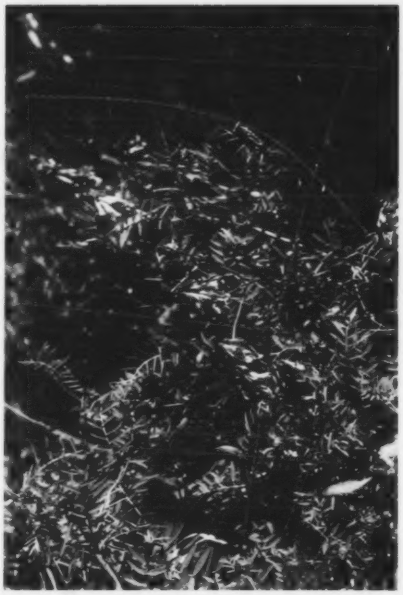
Fenugreek is an herb that can be grown as an annual forage crop in Alberta. Its primary uses are as a food condiment and flavoring agent, and it also has uses in the pharmaceutical industry. It is sometimes grown to replace alfalfa as a feed source. A forage variety has been developed. Fenugreek is adapted to well-drained soils where growing temperatures range from 8 to 27°C. Establishment is slow and weak when grown in cold wet soils. This crop is best suited to the irrigated areas. Weed control may be a problem.

FENUGREEK

OTHER FORAGE LEGUMES

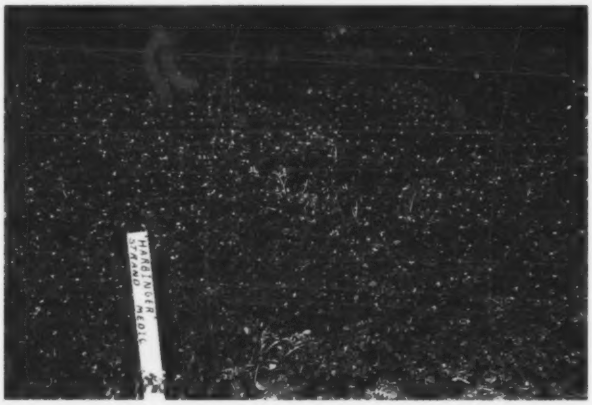
Most of the annual legumes originated from the Mediterranean region and are grown as winter annuals in the southern United States. These annuals include the annual medics *Medicago* spp. (i.e. black medic, snail medic, strand medic), the annual clover *Trifolium* spp. (crimson clover, berseem clover, rose clover, arrowleaf clover, persian clover) and the annual vetches Vicia spp. (hairy vetch, winter vetch, common vetch). Many of these have been tried in Alberta for use as annual forage.

There are establishment problems and weed problems that must be overcome to be successful. As with most legumes, soil pH, the proper rhizobia strain and bloat are issues. The advantage most of these crops do have over the traditional annual legume such as field peas is that they will regrow after cutting. These crops have limited potential and are most adapted to irrigation areas.

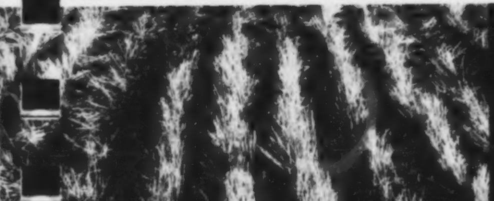


HAIRY VETCH

CRIMSON CLOVER



STRAND MEDIC



PERENNIAL FORAGE ESTABLISHMENT

Perennial Forage Establishment

Successful forage establishment begins a year or two before seeding. Forages should be seeded on fields that are free of perennial weeds. Controlling perennial weeds is more effective and less costly when done in annual crops as compared to controlling weeds in newly seeded forage stands.

Factors that affect forage establishment:

- species and variety selection
- pre-seeding perennial weed control
- seed quality
- type of crop stubble
- cropping history
- seedbed preparation
- soil fertility
- seeding date
- seeding rate
- seeding depth
- companion cropping
- weed control
- seeding techniques

Successful forage establishment produces stands that are uniform, vigorous and productive.

Species Selection

The first step in forage establishment is identifying the end use of the forage crop. Some species are better suited for hay or silage production while others are better for pasture production (see Species sections). The time of year the pasture may be needed may affect the species selected as some species are more suited for early spring grazing, others for summer grazing and some for stockpiling material for late fall or early spring grazing (Figure 42 and 43).

Perennial species differ in their growth patterns throughout the growing season and can be used to increase the length of the grazing season. Some forages are better suited than others for pasture rejuvenation and soil conditioning. The species grown will also affect the hay markets available.

FIGURE 42
Spring grazing stockpiled forage

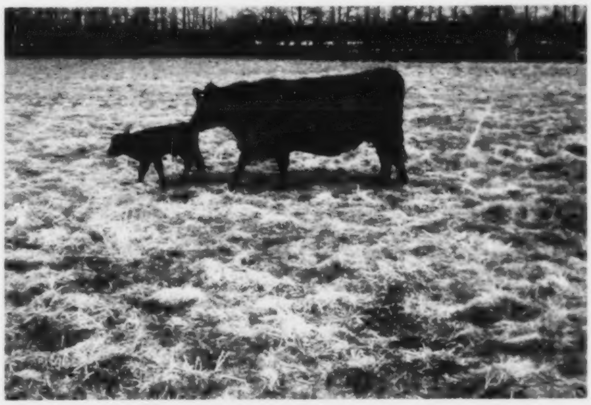
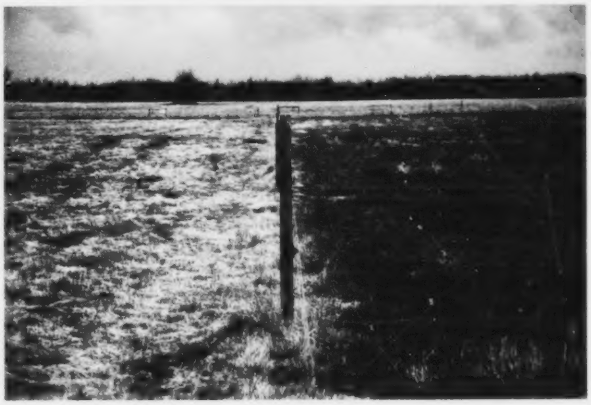


FIGURE 43
Spring growth of creeping red fescue (left) and meadow bromegrass (right)



Once the correct species is selected for the end use, ensure it is adapted to the climatic and soil conditions where it will be seeded. Species grown in the drier areas and Brown soil zones of Alberta will differ from those grown in areas receiving higher levels of precipitation such as the Black and Gray Wooded soil zones in central and northern Alberta and the irrigated areas of southern Alberta.

Species differ in tolerance to poorly drained soils, soil pH, salinity, alkalinity, and texture (Table 1 in the Forage Adaptation section). Other factors to consider include longevity, winter hardiness and yield potential.

Species mixtures can be simple or complex. In most cases, a legume with one or two grass species is all that is required. Pastures containing a minimum of 30 to 40 per cent legume can usually produce sufficient nitrogen to meet the nitrogen requirements of the forage stand assuming grazing and manure are evenly distributed across the field. Hay or silage fields should contain higher percentages of legumes as the nutrients are removed from the field at harvest. The addition of alfalfa in a mix will also provide more uniform growth during the growing season, increased productivity during drought and higher feed quality.

FIGURE 44
Yellow-flowered alfalfa in mixed forage stands (on right) can provide nitrogen to the grass

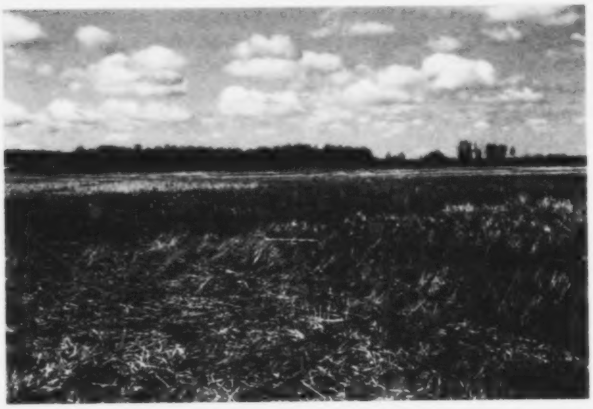
Consideration should also be given to the method of seeding when selecting a species. Broadcast seeding with no seed incorporation requires forage species with good surface germination. Timothy, clovers and orchardgrass are better surface germinators than most other forage species.

Weed Control Before Seeding

Perennial weeds must be controlled before establishment. These weeds are competitive with forages during establishment and can reduce yields and quality of the forage crop in subsequent years. Perennial weeds are difficult and more costly to remove once the stand is established and the herbicide selection is reduced, especially in grass legume mixtures.

The field should be free of perennial weeds such as quackgrass, Canada thistle, toadflax, foxtail barley, dandelions, etc. Most perennial weed problems can be managed by applying glyphosate pre-harvest or post-harvest in annual cropping rotations for several consecutive years before planting forages. Annual weeds should be controlled by using appropriate herbicides or tillage prior to planting.

FIGURE 45
Pre-harvest glyphosate (left) in annual crops applied the year before seeding forages will help reduce perennial weeds such as quackgrass, dandelions and Canada thistle



Know the cropping history and associated cultural practices of the site. Previously applied residual herbicides can seriously affect grass and legume seedlings. The amount of residue will vary depending on soil type, moisture, organic matter and soil pH. To avoid problems, read the herbicide label for current, detailed information on forage cropping restrictions.

Seed Quality

The quality characteristics of forage seed are determined through testing by a licensed seed analyst. Based on the test results, a certificate of analysis is issued that provides a description of the seed, grade, germination rate, hard seed (for legumes) and the amount of pure live seed, expressed as percentage of the total. Forage seed sold in Canada is classified as follows:

1. Breeder Seed
2. Foundation Seed
   - Canada Foundation No. 1
   - Canada Foundation No. 2
3. Certified Seed
   - Canada Certified No. 1
   - Canada Certified No. 2
4. Common Seed
   - Canada No. 1 Seed
   - Canada No. 2 Seed

Breeder, Registered, Foundation and Certified seed are classified as Pedigreed seed as the particular variety of the species is known. Classifications under each grade are generally related to differences in types and numbers of weed seeds and germination. Breeder and Foundation seed are used to propagate seed of a particular variety. Forage seed purchased in Canada for hay or pasture is sold as Certified or Common seed (Figures 46 and 47). Purchasing Certified seed will ensure the variety purity, high germination and limit the impurities in the seed.

A seed certificate of the analysis should be requested when purchasing seed, regardless of the grade of seed being purchased. For further information on the topic, see Alberta Agriculture and Rural Development's factsheet *How to Purchase High Quality Forage Seed*, Agdex 120/45-1.

FIGURE 46
The colour of the tags attached to bags will indicate whether the seed is certified (blue) or common (white)

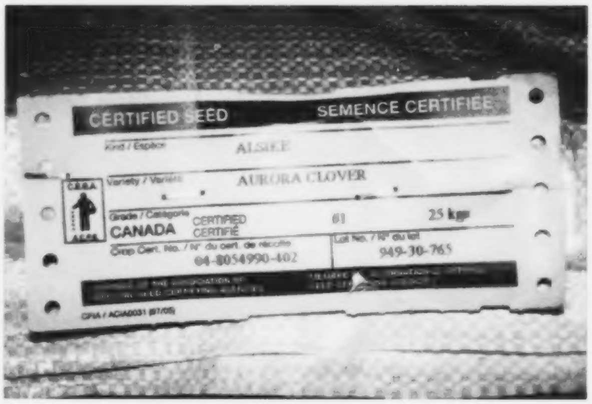
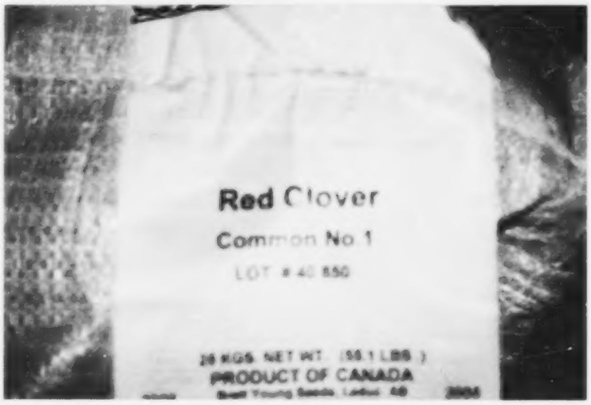

CERTIFIED SEED
SEMENCE CERTIFIEE
Kind / Espèce
ALSIKE
Variety / Variété
AURORA CLOVER
C.S.G.A.
A.C.P.S.
Grade / Catégorie
CANADA
CERTIFIED
CERTIFIÉ
01
25 kg
Crop Cert. No. / N° du cert. de récolte
04-8054990-402
Lot No. / N° du lot
949-30-765

FIGURE 47
Tags on seed bags will indicate grade, species, variety (if certified) and lot number


Red Clover
Common No 1
LOT # 40 550
PRODUCT OF CANADA

The percentage of hard seeds is reported on seed certificates in legumes. Hard seeds do not readily absorb moisture and, therefore, do not germinate quickly. The embryo is usually viable, but seeds may remain dormant for several weeks, months or years until the hard seed covering cracks and allows moisture to be absorbed. Variety, geographical location, climatic conditions during seed production and harvest management are all factors that affect the amount of hard seed in a lot.

Inoculation of Legumes

Legumes require inoculation with rhizobia bacteria to properly fix atmospheric nitrogen (see Fertility section). Soils may have some rhizobium present from previous crops but inoculating the seed ensures high numbers of rhizobium will be available. Commercial inoculants contain strains of rhizobia in a carrier that supports and protects the rhizobia until placed in the soil. Forms of inoculants include peat and clay based and are applied as powdered, coated or granular (Figure 48).

Legume Inoculants

- Alfalfa group – *Rhizobium meliloti* for alfalfa and sweetclover
- Clover group – *Rhizobium trifolii* for red clover, white clover and alsike clover
- Sainfoin – *Rhizobium spp.* (species-specific strain)
- Birdsfoot trefoil – *Rhizobium loti*
- Cicer Milkvetch – *Rhizobium spp.* (species-specific strain)
- Kura clover – *Rhizobium spp.* (species-specific strain for kura)

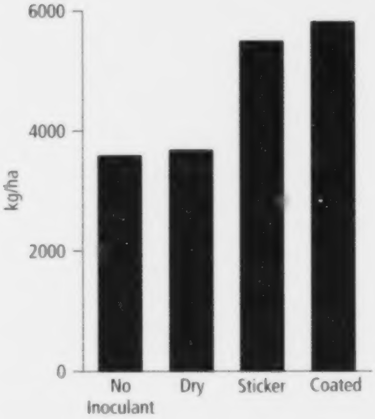
FIGURE 48
A number of different commercial inoculants are available

Soil
Implant+
Nitragin-Brand Inoculant For ALFALFA
GRANULAR
NET WEIGHT: 18 KG (40 LB)
LiphaTech
STORE FLAT UNTIL READY TO USE
IMPORTANT

The majority of legume seed purchased comes pre-inoculated. Verify that the pre-inoculated seed you are buying has not expired and is specific for the crop to be sown.

If inoculating on farm, use a sticker solution and mix seed thoroughly to ensure the inoculant adheres to the seed (Figure 49). Inoculants are available that stick to the seed without having to mix a sticker solution.

FIGURE 49
Effects of methods of inoculation on alfalfa yields – Beaverlodge (soil pH 5.8)



W.A. Rice Et al.Can.J.Soil.Sci.63:541-545

Consider using a fungicide when establishing forage legumes under cool, damp conditions to protect both seed and seedlings from fungal diseases. Ensure the fungicide will not interfere with the rhizobia inoculant applied with the seed.

Time of Seeding

Seeding should take place when soil moisture conditions are good. Early spring seeding results in better stand establishment than late summer seedings and may provide a hay cut or light grazing in the fall after the forage is dormant.

While the exact dates will vary throughout the province, seeding between May 1 and June 15 is typically the ideal time to seed. Seeding early will take advantage of spring soil moisture and early precipitation. Optimum soil temperatures for germination will range from 10° C to 20° C, although germination can occur as low as 5° C. Early seeding allows the forage to establish throughout the growing season. The later the forage is seeded, the higher the risk of failure to establish.

Late summer seeding is best suited to irrigation. Under dryland conditions, forages have been seeded as late as September 1 and established well, but conditions may not always be suitable to be successful. If seeding late, soil moisture and growing conditions must be ideal for quick establishment and sufficient plant growth before a killing frost. Late seeding can be very hazardous if insects are present or if the soil is excessively dry. Grasses and legumes must have sufficient leaf and root development before freeze-up, and six to eight weeks of growth is usually required. Grasses should develop to at least the two-leaf stage and preferably the three-leaf stage before freeze-up to ensure high winter survival rates (Table 19). Alfalfa seedlings should also be at the two-leaf stage to minimize overwintering losses (Table 20).

Winter survival of forage seedlings following late summer or early fall seedings is higher when seeded into stubble as compared to seeding on summerfallow, especially when forage seedlings are at an immature stage of development.

TABLE 19
Stage of development and per cent winter survival of three grasses seeded into summerfallow and stubble (average of four years)

Growth Stage Prior to Winter	Seedbed Condition Fallow	Stubble
	% Survival	% Survival
No emergence	19	51
1 leaf up to 1/2 in.	23	66
1 leaf over 1/2 in.	50	77
2 leaves up to 2 in.	77	84
2 leaves over 2 in.	69	96
3 or more leaves	93	100

W.J. White and W.H. Horner: Scientific Agriculture, March, 1943

TABLE 20
Stage of development and per cent winter survival of alfalfa seeded into stubble (average of two years)

Growth Stage Prior to Winter	% Survival
Cotyledons only	21
1 leaf	60
2 leaves	81

Adapted from W.J. White and W.H. Horner (1943)

Dormant seedings, just before freeze-up, can work, but for the seeding to be successful, the soil temperature must be below 2° C to prevent germination. Forage establishment using dormant seeding is more successful when the forages are seeded into stubble. This approach reduces the risk of soil crusting in the spring when the seed germinates, protects the soil from erosion and provides excellent moisture conditions for developing seedlings in the spring.

Fertility During Establishment

Fields should be soil tested before seeding forages to determine soil pH and nutrient levels. Fertility is important to developing seedlings although usage will be less than established stands. Legumes or grass legume mixtures have higher requirements for phosphorous, potassium and sulphur than grass stands.

Banding or broadcasting large amounts of phosphate, potash and sulphur into the seedbed before seeding can provide adequate nutrients for several years of forage production. This method is expensive initially but reduces the need to fertilize for several years. Grass stands will still require an annual rate of nitrogen to maintain production. In areas that receive adequate moisture, nutrient deficiencies can be corrected by broadcasting fertilizer on established stands (see Fertility section).

Phosphate fertilizer can be mixed with forage seed to provide extra volume and density. This approach will help maintain seed flow in drill metering systems and also permit the seeding of forage species, such as Kentucky bluegrass, that have a low seeding rate. Fertilizer seed mixtures should be seeded as soon as possible after mixing to avoid seed injury.

Placing phosphorous with the seed can help the new seedling develop into a healthy plant, particularly under cool, moist conditions. Low rates of phosphate fertilizer, 15 kg/ha, can be placed with the seed at the time of seeding. If the seeding equipment can scatter the fertilizer over a wider area or band it separately, then higher amounts can be used.

Sulphur deficiencies can be corrected by either banding or broadcasting sulphate sulphur before seeding. Elemental sulphur broadcast on the soil surface without incorporation is also effective although a one to two-year delay in response may be seen. Although both grasses and legumes will benefit, legumes have a greater requirement for sulphur.

The use of seed-placed nitrogen should be minimal, as seedling emergence has been reduced by 30 per cent when nitrogen was applied at a rate of 30 kg/ha (Table 21). Excessive nitrogen during establishment may also lead to excess weed growth.

TABLE 21
Effects of seed-placed nitrogen on timothy emergence

	Seedling Emergence as % of Check	
Rate of Nitrogen Kg/ha	**Urea (46-0-0)**	**Ammonium Nitrate (34-0-0)**
0	100	100
30	65	70
60	36	40
120	0	0
120*	96	102

*Nitrogen fertilizer was broadcast and worked to a depth of 5 cm (2 in.) before seeding.

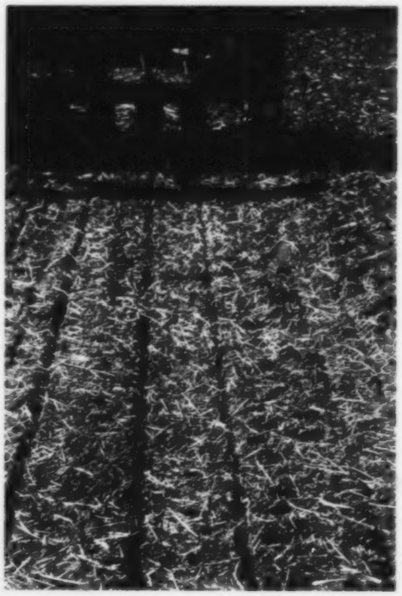
Bailey, L.D. Brandon Research Station Report

Seedbed and Seeding Systems

TILLED SEEDBEDS

Forage seeds are very small and require a firm seedbed, allowing for a shallow, uniform seeding depth. This approach ensures the seed has close contact with soil moisture, resulting in rapid germination and early seedling root growth. When a seedbed is properly packed, tractor tire marks will be barely visible (Figure 50). Seedbed preparation the previous fall or very early in the spring promotes the germination and control of weed seeds and reduces soil moisture losses from excessive tillage.

FIGURE 50
Seeding forages into a firm, tilled seedbed ensures rapid germination and emergence



Sod from recently cultivated old forage stands will result in a loose fluffy seedbed. Under dry conditions, this type of seedbed will reduce establishment success. If a field is particularly "soddy," it might be beneficial to seed an annual crop and defer seeding forages until the following year to allow further sod decomposition.

DIRECT SEEDING INTO STUBBLE

Direct seeding into annual crop stubble provides many benefits for newly emerging forage seedlings (Figures 51 and 52). Standing stubble reduces evaporation at the soil surface, prevents soil erosion, reduces soil crusting and provides some shade for the emerging seedlings. Undisturbed fields are also firm, which helps in providing depth control for seeding equipment and good seed-to-soil contact.

FIGURE 51
Direct seeding grasses into canola stubble is an excellent establishment method

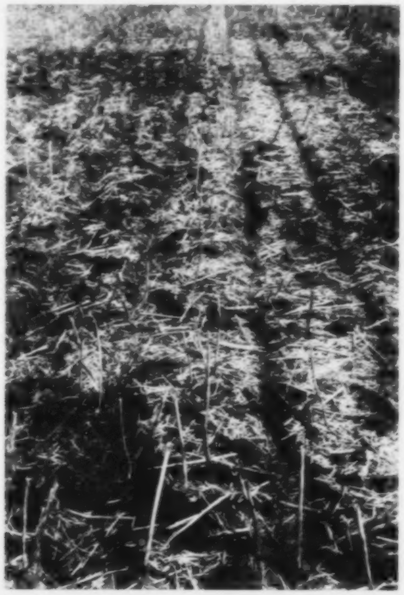
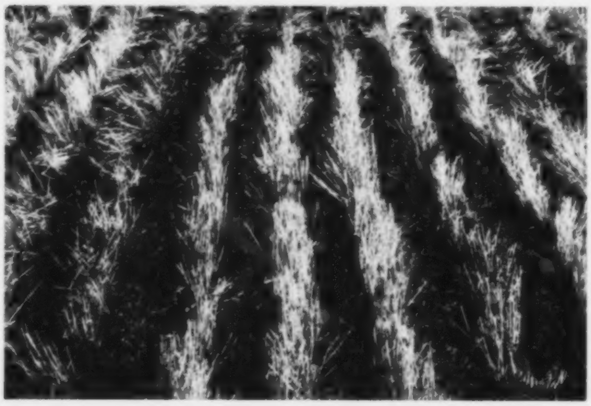


FIGURE 52
Direct seeding alfalfa into cereal stubble has proven to be an effective practice for stand establishment



In annual crop stubble, good management of the straw and chaff from the preceding crop is important. Excess residue in the drill row can affect seeding uniformity and reduce germination. Chaff and straw from the previous annual crop should either be removed by baling or chopped and spread as evenly as possible during combining (Figure 53). Field harrowing after harvest can also be used to help spread straw and chaff. Most disc, knife or hoe openers can be used in annual crop stubble to seed forages (Figure 54).

FIGURE 53
Chaff and straw that are not spread uniformly across the field will reduce the emergence of forages and have long lasting effects on the stand

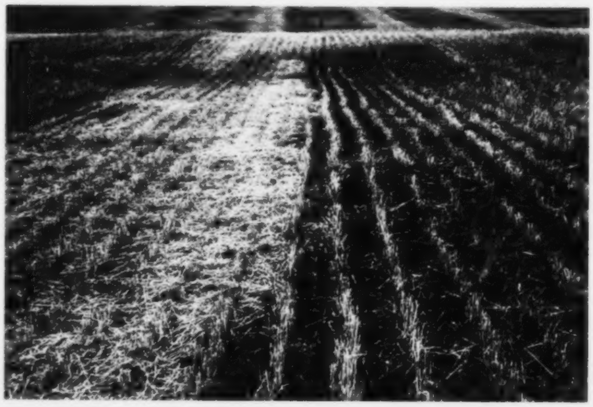


FIGURE 54
Many of the new direct seeding drills with disc type openers have excellent depth control for seeding forages

Canola or pea stubble is more successful for direct seeding grasses than cereal stubble since there is less crop residue and less competition from volunteer plants if proper herbicides are used. Previous stubble type does not affect alfalfa establishment. In a study, meadow bromegrass established better on canola or pea stubble as compared to wheat stubble (see Table 22).

The reduced emergence of meadow bromegrass on wheat stubble was attributed to high levels of wheat residue, root disease and possibly allelopathic effects from decaying wheat residues. Previous stubble type did not affect forage yields the year after seeding. Direct seeding into cereal silage or greenfeed stubble would reduce the problems of poor seed-to-soil contact that results when high levels of crop residue are present.

TABLE 22
Influence of previous crop type on stand establishment of alfalfa and meadow bromegrass 1990 and 1991

Previous Crop Type	1990 Plants/m² 21 Days After Seeding	1991 Plants/m² 25 Days After Seeding
	Alfalfa	
Canola	38	29
Pea	34	27
Wheat	26	29
	Meadow Bromegrass	
Canola	67	33
Pea	68	26
Wheat	12	10

C.L. Allen and M.H. Entz: Can.J.Plant Science 1994

When direct seeding forages, use a glyphosate product before and/or after seeding, but before seedling emergence. Forage establishment will be affected if the field is too weedy (see Weed Control section).

BROADCAST SEEDING

Broadcast seeding is a quick and efficient method of seeding. When underseeding forages to a companion crop, overseeding existing pastures or establishing forages where drills cannot be used, such as logged over areas, broadcasting may also be effective. Boom type spreaders, airplanes or helicopters and spinner applicators are common application methods for broadcasting seed. New models of air drills with hoe-type openers may have an additional tank that will send seed to deflectors in front of the seed openers and spread seed between the rows of the annual crop being seeded. These openers should provide sufficient soil disturbance followed by packers to ensure good seed-to-soil contact.

Traditional spinner spreaders can be used to apply forage seed, but due to differences in seed weight and size, it can be difficult to spread accurately and evenly with this equipment. Fluffier seeds such as smooth bromegrass are not broadcast as far as heavier seeds such as alfalfa or clover. This discrepancy can lead to an uneven distribution of forage species within the stand. For this reason, producers are using a dribble type of boom spreader with either air or mechanical distribution systems. Floaters, Tera-Gators and Velmars are included in these types of systems (Figure 55).

FIGURE 55
Commercial floaters provide even distribution of seed and fertilizer when overseeding pastures or broadcast seeding on cultivated land

Accuracy of seed distribution is generally very good and may permit the application of fertilizer at the same time. Carriers such as a phosphate fertilizer are used to help with flow and to even out seed application, particularly with awned species like the bromegrasses.

On cultivated land, the field should be harrow-packed, harrowed or rolled after spreading the forage seed. This final operation is needed to cover the seeds with soil and to provide good seed-to-soil contact. Seeds must absorb water from the soil to germinate. Poor soil contact can result in poor germination. Leaving crop residue on top of the surface will reduce problems with soil crusting and keep the moisture at the surface.

Under conditions where broadcasted seed cannot be incorporated, forage species with good surface germination such as timothy, clovers and orchardgrass may be more successful (Figure 56).

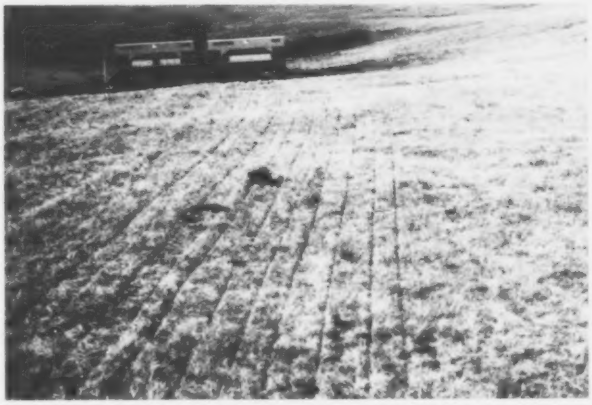
FIGURE 56
Stand establishment following broadcasting forage seed on logged-over areas

Brillion seeders are also utilized for seeding forage crops. These specialized seeders are equipped with two corrugated rollers that pack before and after seed application, maintaining proper seed placement as well as providing good seed-to-soil contact. These seeders are best suited to well tilled soils and leave the soil surface very smooth. Seedling emergence problems may occur on heavy clay soils, which tend to crust after heavy rains.

SOD SEEDING

Results on seeding forages into existing forage stands have been variable. Old roots and top growth can make it difficult to obtain good seed placement (Figure 57). Existing plants compete for moisture and nutrients with the newly seeded forages resulting in inconsistent and uneven seedling establishment. It is important to suppress the old forage stand by spraying with a non-selective herbicide in advance of re-seeding to provide time for sod decomposition (see Rejuvenation section).

FIGURE 57
Establishment of forages by direct seeding forage seed into sod has been variable



Disc or narrow knife openers with cutting coulters are generally best suited for seeding into sod. Hoe openers tend to tear the old sod leaving a rough hay field or pasture. Good in-row packing is required to ensure that the slot is closed and the seed is covered with soil.

The lack of good seedbed conditions, disease, weeds or autotoxicity from prior crops often limits the immediate re-seeding of forages. The use of an annual cereal crop after the removal of a forage stand to allow time for the sod to break down is often a better option than trying to re-seed a perennial forage crop into an existing forage stand.

Seeding Rates

Forage seed size is variable within species, types, varieties and seed coatings. Seed size may also be affected by growing conditions when the seed was produced. Seed size will affect seeds per kilogram, with smaller seeds having more seeds per kilogram. Species having tetraploid varieties have a significantly larger seed and seeding rates should be higher than for diploid varieties.

Table 23 provides seeding rates that are intended to be a guideline for on-farm use. There is a fairly broad range of seeding rates that will give similar satisfactory forage yields. Forage plants in less dense stands have more tillers per plant than those in denser stands when growing conditions are favourable. Poor seedbeds, depth of seeding, etc. should be corrected rather than seeding at higher rates to compensate for poor emergence.

The rates in Table 23 are satisfactory for seeds having a germination rate of 80 per cent or higher. The seeding rates for lower germination seed should be adjusted upwards. Pure live seed (PLS) can be determined by accounting for the per cent germination of the seed and the per cent pure seed. This information is available from the seed test certificate supplied with the seed.

DETERMINING PURE LIVE SEED

If a PLS percentage is not available, use the following formula:
% PLS = (% germination x % pure seed) ÷ 100

Example
Alfalfa with 85% germination and 98% pure seed.
(85 x 98) ÷ 100 = 83.3% PLS

This sample would have 83% PLS

Somewhat lower seeding rates may establish satisfactorily under ideal establishment conditions. Ideal conditions include a clean firm seedbed, precision seeding equipment, shallow depth control, good moisture conditions and no competition from weeds or a companion crop. Creeping species may be seeded at lower rates in mixtures since they will thicken up with time. Some forages have more vigorous seedlings than others.

Species with smaller seeds are seeded at higher densities to compensate for lower rates of emergence and higher seedling mortality. Legume seeds lots with a hard seed count of 25 per cent or more should be seeded at higher rates. Forage crops intended as seed crops need a much lower seeding rate than crops intended for forage production. Poor establishment generally means poor production for the life of the stand. It is very difficult to improve a poor stand of forage.

TABLE 23
Seeding rates for single species forage stands[1, 2]

	Seeds/kg (Seeds/lb)	Seeds/m² (Seeds/ft²)	Seeding Rate kg/ha (lb/ac)	Seeds/Row Per Meter (Per Foot)
Legumes				
Alfalfa	441,000 (200,000)	400 (40)	9 (8)	60 (20)
Birdsfoot Trefoil	827,000 (375,000)	750 (70)	9 (8)	110 (35)
Cicer Milkvetch	287,000 (130,000)	425 (40)	15 (13)	65 (20)
Clover, Alsike	1,544,000 (700,000)	875 (80)	6 (5)	130 (40)
Clover, Red	606,000 (275,000)	400 (40)	7 (6)	60 (20)
Clover, Sweet	573,000 (260,000)	575 (55)	10 (9)	90 (30)
Clover, White	1,764,000 (800,000)	1,000 (90)	6 (5)	150 (45)
Clover, Kura	474,000 (215,000)	475 (45)	10 (9)	72 (22)
Sanfoin (pods on)	66,000 (30,000)	225 (20)	34 (30)	35 (10)
Grasses				
Bromegrass, Hybrid	200,000 (91,000)	275 (25)	13 (12)	40 (10)
Bromegrass, Meadow	182,000 (83,000)	300 (30)	16 (14)	45 (15)
Bromegrass, Smooth	300,000 (136,000)	275 (25)	9 (8)	40 (10)
Fescue, Creeping Red	826,000 (375,000)	475 (40)	6 (5)	70 (20)
Fescue, Meadow	507,000 (230,000)	450 (40)	9 (8)	70 (20)
Fescue, Tall	501,000 (227,000)	450 (40)	9 (8)	70 (20)
Foxtail, Creeping	1,657,000 (752,000)	745 (69)	4 (4)	111 (35)
Foxtail, Meadow	1,270,000 (576,000)	700 (65)	6 (5)	105 (35)
Kentucky Bluegrass	4,800,000 (2,177,000)	2,700 (250)	6 (5)	400 (125)
Orchardgrass	1,442,000 (654,000)	1,290 (120)	9 (8)	195 (60)
Reed Canary Grass	1,175,000 (533,000)	800 (75)	7 (6)	120 (40)
Ryegrass, Italian	501,000 (227,000)	850 (80)	17 (15)	125 (40)
Ryegrass, Perennial	501,000 (227,000)	850 (80)	17 (15)	125 (40)
Timothy	2,712,000 (1,230,000)	1,225 (115)	4 (4)	180 (55)
Wheatgrass, Crested (D)[3]	480,000 (218,000)	325 (30)	7 (6)	50 (15)
Wheatgrass, Crested (T)[3]	360,000 (163,000)	325 (30)	9 (8)	50 (15)
Wheatgrass, Intermediate	194,000 (88,000)	225 (20)	11 (10)	35 (10)
Wheatgrass, Northern	340,000 (154,000)	275 (25)	8 (7)	40 (10)
Wheatgrass, Pubescent	221,000 (100,000)	250 (25)	11 (10)	40 (10)
Wheatgrass, Slender	351,000 (159,000)	325 (30)	9 (8)	50 (15)
Wheatgrass, Tall	174,000 (79,000)	325 (20)	13 (12)	35 (10)
Wheatgrass, Western	243,000 (110,000)	275 (25)	11 (10)	40 (15)
Wildrye, Altai	121,000 (55,000)	200 (20)	16 (14)	30 (10)
Wildrye, Dahurian	192,000 (87,000)	250 (25)	13 (12)	40 (10)
Wildrye, Russian	386,000 (175,000)	350 (30)	9 (8)	50 (15)

[1] These are approximate guidelines to be used for seeding.

[2] Adapted from Forages – The Science of Grassland Agriculture, 3rd edition, Heath, Metcalf and Barnes

[3] Crested wheatgrass can be a diploid (D) or a tetraploid (T).

Variations in seed size, seed density and seed surface features, such as awns, often result in seed settling out of mixtures or separating during auguring or metering. Seeds that are long, fluffy or have awns may bridge in drills.

Forage mixtures should use proportionate amounts of seed for each component, depending on what is desired in the forage stand. Aggressive species are sometimes seeded at lower proportions when mixed with non-aggressive species. For example, a mix made up of 75 per cent of the alfalfa seeding rate and 25 per cent of the bromegrass seeding rate may be appropriate. The smooth bromegrass is an aggressive creeper, which will thicken the stand over time. When using less aggressive species such as orchardgrass, a mix of 50 per cent of the alfalfa rate and 50 per cent of the orchardgrass rate may make a better mixture.

End use is always a factor in using mixtures. When mixtures are seeded for hay, it may be desirable to have a higher percentage of alfalfa in the stand than when mixtures are utilized as pastures. When determining ratios in a mixture, use a percentage of the seeding rates from Table 23 for each species in the mixture.

Example
A 50:50 mix of alfalfa and meadow bromegrass should have the following:

Metric
50% x 9 kg/ha = 4.5 kg/ha of alfalfa
50% x 16 kg/ha = 8 kg/ha of meadow bromegrass
12.5 kg/ha of this mixture would need to be seeded to have a 50:50 alfalfa x meadow bromegrass mixture

or

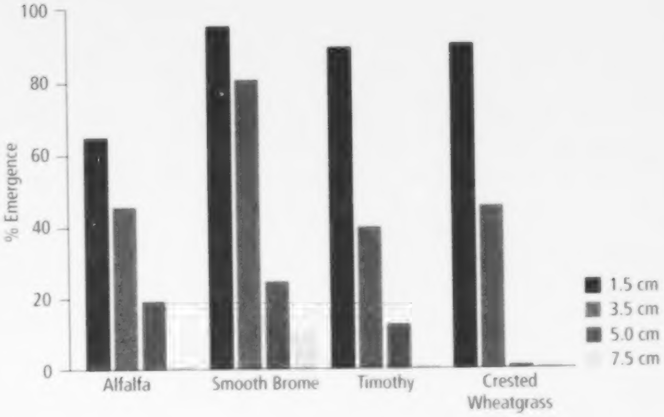
Imperial
50% x 8 lb/ac = 4 lb/ac of alfalfa
50% x 14 lb/ac = 7 lb/ac of meadow bromegrass
11 lb/ac of this mixture would need to be seeded to have a 50:50 alfalfa x meadow bromegrass mixture

Depth of Seeding

Seeding depth is related to seed size, soil texture and moisture conditions. Seeding too deep will result in poor seedling emergence and is often the major reason for establishment failures. Most forage seeds are very small and do not have enough energy to emerge from deep seedings.

Care should be taken to place the seed at 1 to 2 cm (1/2 - 3/4 in.) into a firm seedbed. For small seeded species such as timothy, shallow seeding is very important to ensure emergence. Figures 58 and 59 illustrate the effect seeding depth has on forage seedling emergence.

FIGURE 58
Effect of seeding depth on percentage emergence of several different species



There was no emergence from alfalfa, timothy and crested wheatgrass when seeded at the 7.5 cm depth. Crested wheatgrass was not seeded at the 5 cm depth.

K.W. Clark (1977) as cited by G.R. Winter (1981) Management of Forage Systems Efficiency of Forage Production in Canada Vol. 1. Olds College Publisher

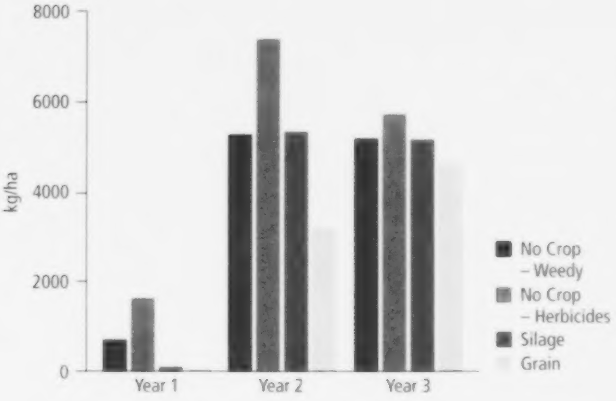
FIGURE 59
Effect of seeding depth on timothy the year after seeding
Left to right: 2.5 cm (1 in.) versus 1.25 cm (1/2 in.)

Companion Crops

Although the use of companion crops provides some economic returns during the year of forage establishment, the crops compete for light, moisture and nutrients with forage seedlings. Using a companion crop increases the risk that many forage seedlings will not survive the establishment year. This reduction in forage seedling density leads to thin stands, reduced forage yields and increased weediness.

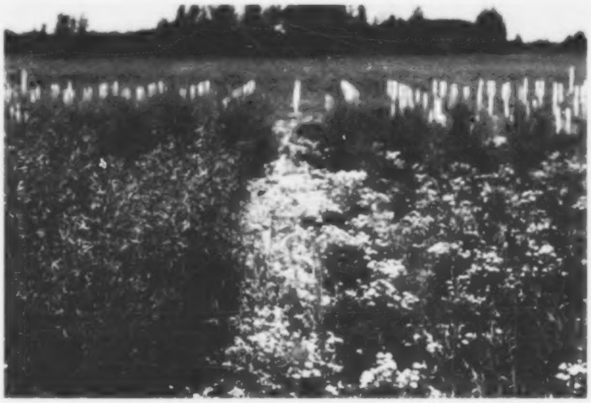
The effects of the companion crop on forage yields may be seen for at least two years following establishment (Figures 60 and 61). Selecting less competitive companion crops and removing the crop early as silage or green feed will help reduce the negative effects the companion crop has on forage stand establishment (Figure 62). Effects of companion crops on subsequent forage stands under irrigation may be less than under dryland conditions. Companion crops may be used when there is a risk of soil erosion from wind or water.

FIGURE 60
Effect of barley companion crop on alfalfa/bromegrass forage yields over a three-year period



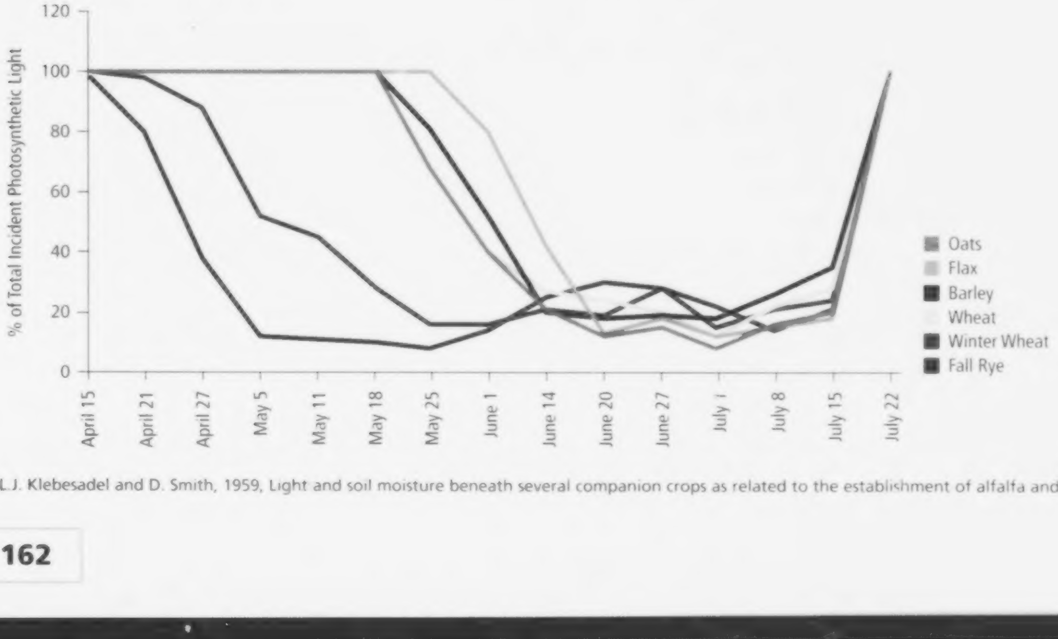
Cole et al. Can.J.Plant Sci.75:121-127

FIGURE 61
Effect of barley companion crop harvested for grain on forage establishment and weeds the year after seeding



NO COMPANION CROP ON LEFT – COMPANION CROP ON RIGHT

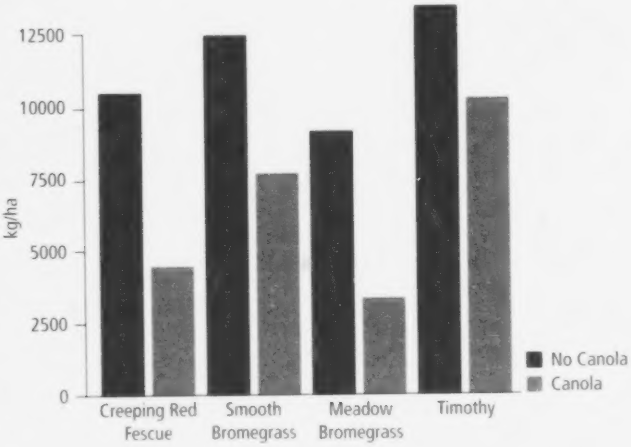
FIGURE 62
Light penetration under various companion crops at different stages of maturity



L.J. Klebesadel and D. Smith, 1959, Light and soil moisture beneath several companion crops as related to the establishment of alfalfa and red clover

There are differences among grass species in their tolerances to seeding with a companion crop (Figure 63). First-year timothy yields are affected less by a canola companion crop than smooth bromegrass, creeping red fescue and meadow bromegrass. Legumes such as alsike clover or red clover are less affected by companion crops than alfalfa.

FIGURE 63
Forage yield of several grass species the year after seeding with and without a canola cover crop

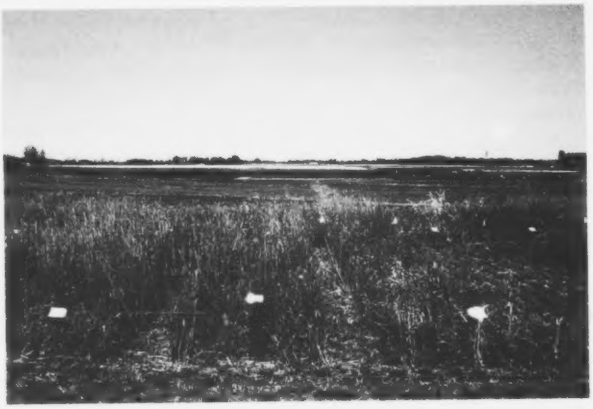


Cole et al., Canadian Weed Science Society Research Report

The decision to use a companion crop should focus on minimizing the effect from companion crop competition on forage seedling establishment. The following aspects can help reduce the effect of competition from companion crops:

- Only seed a companion crop if soil erosion is a concern or it is essential that you produce a silage or greenfeed crop.
- Reduce the seeding rate of the companion crop to less than 50 per cent of the normal rate used for grain or forage production.
- Reduce the amount of nitrogen fertilizer applied to the companion crop to prevent lodging and reduce competition.
- Use less competitive crops such as triticale, wheat, canola, flax or early maturing oat or barley varieties.
- Do not underseed forages with low seedling vigour such as Russian wildrye, cicer milkvetch or native species.
- Seed the crop early and remove the cover crop at the early dough stage for silage or greenfeed. This removal will open up the canopy and provide more time for the forage seedlings to recover before winter (Figure 64).
- If the companion crop is removed as grain, remove the straw from the field or chop and spread it. If the straw is left in a windrow, it will smother the seedlings growing under it.
- Know what weeds are present in the field and what in-crop herbicides are compatible with both the forage seedlings and companion crop before seeding.

FIGURE 64
Forage establishment the year after seeding when seeded alone (left), with oats harvested for silage (middle) and with oats harvested for grain (right)



If seeding without a companion crop, consider the following points:

- Seed early to maximize forage yields after dormancy in the fall.
- Direct seed into annual crop stubble.
- Control weeds with herbicides or mowing, making sure that the clippings will not smother the seedlings.

Weed Management

Weeds can jeopardize the establishment of perennial hay and pasture crops. Persistent perennial weeds such as Canada thistle, yellow toadflax, dandelion, ox-eye daisy, common tansy, quackgrass, foxtail barley and any poisonous plants should be controlled in the years before seeding. Pre-harvest or post-harvest glyphosate in annual crops in the year before seeding can provide long-term control of many of these weeds. Before seeding a perennial hay or pasture crop, it is important to check the field records for prior residual herbicide applications to avoid possible injury to the crop. Verify the crop seeding restrictions for residual herbicides in Alberta Agriculture and Rural Development's Crop *Protection* (Agdex 606-1), which is updated annually.

If seeding forages without a companion crop, a glyphosate product before and/or after seeding, but before seedling emergence, is an effective method of weed control. Table 24 shows the benefit of applying glyphosate before or shortly after direct seeding timothy to remove early weed competition.

TABLE 24
Timothy forage yields in September of the establishment year following pre-seeding and pre-emergent applications of 1 L/acre of glyphosate (360 g/L) when direct seeding timothy

Timing of Glyphosate Application	Timothy Forage Yield % of Untreated Check	
	Beaverlodge	Edmonton
Within 5 days Prior to Seeding	197	87
Within 5 days After Seeding	205	214
Untreated Check	100	100

2003.-CWSS reports Cole and Yoder

When purchasing certified forage seed, producers need to ask the seed supplier for the seed certificate to check for seeds of noxious weeds and unwanted weeds that may be present in the seed. This step can avoid a very costly problem in the future.

If the perennial hay or pasture crop has to be seeded into a field that is known to be weedy, certain steps should be taken:

- Plan ahead so that you know there are options for managing the weeds. For example, do not seed timothy and alfalfa with canola as the cover crop as there may be no herbicide options for managing broadleaf weeds.
- Delay seeding to control weeds before seeding.
- Consider using a pre-seed or pre-emergent herbicide to control weeds (Table 24).
- Pre-emergent herbicides may be used on some legumes to control weeds.
- Avoid planting legumes where there is a heavy infestation of broadleaf weeds and avoid planting grasses where there is a heavy infestation of grassy weeds as herbicide options will be limited.
- Post-emergent herbicides are available to control weeds after emergence.
- Mowing weeds can also work well to help manage competition from weeds.
- Establish and maintain a competitive forage stand.

Clipping weeds off just above the forage will remove the seed heads and open up the canopy for the forage seedlings.

If the volume of weeds is high, use a swather, and soon after swathing, bale up and remove the clipped weeds from the field. If the swaths are left on the field, they will smother the forage seedlings. Mowing or clipping is not an option when a companion crop is seeded with the forage crop.

Annual and winter annual weeds usually grow quickly and compete with the perennial forage crop and should be controlled to allow the forage to establish. If herbicides are used, follow label directions closely and be aware of grazing and feeding restrictions for each herbicide.

Evaluating New Stands

Forages seeded without a cover crop can be monitored for establishment and stand density within 90 days of seeding. Forages underseeded to a companion crop should be evaluated after crop removal. Evaluations should also be done in the spring of the year after seeding to confirm stand density. If the number of established seedlings is too low for a successful stand, direct seeding into the existing seedbed may still be possible.

Some caution should be used in evaluating forage seedings. Drought, cover crop competition, seedbed conditions or the seedling vigour of a forage species can affect seedling establishment. Under some circumstances, seedling establishment may be slow.

New forage seedings are best evaluated by measuring the number of seedlings/m^2 or ft.^{2} Check several locations within a field to confirm the overall seedling establishment. Uniformity of the stand across the field is as important as plant density.

Suggested forage seedling densities for first-year stands are provided in Table 25. The seedling densities reflect good seedling establishment and serve as a general guideline when evaluating stands. Subjective judgment is often required when deciding whether existing plant densities are adequate for a productive forage stand.

Direct seeding with low disturbance air or no-till type drills provides the best option for re-seeding forage stands that have poor stand establishment. These seeders will provide proper seed placement while minimizing disturbance to the existing forage plants.

Direct seeding will also eliminate the need to prepare a new seedbed. Broadcasting can also be used, but proper incorporation of the forage seed may lead to the loss of some of the existing plants.

For best results, re-seeding should occur within the year of seeding or the following spring. For some forage species, such as alfalfa, it is important to re-seed early.

Established alfalfa plants can produce an effect known as autotoxicity, which is a release of autotoxic compounds from existing alfalfa plants. This compound restricts root development in new alfalfa seedlings. As a result, many seedlings die or remain stunted and less productive in subsequent years.

TABLE 25
Suggested seedling density (plants/m^2)

Soil Zones	Legumes	Grass/Legume (50:50)	Grass
Black	80-100	80-100	100-160
Dark Brown	60-100	60-100	100-160
Brown	30-50	20-40	20-40
Gray Wooded	40-50	30-40	40-50
Irrigation	150-250	150-200	200-300

To convert plants/m^2 to plants/ft.^{2}, divide by 10.80

Seedling densities are for the first year after seeding. Plant density may decline further in following years. Seedling densities are suggested minimums to obtain a productive stand.

Seedling density in the moist areas of the Gray Wooded soil zone should be similar to those of the Black soil zones.

Source: Alberta Agriculture and Rural Development, AFSC Crop Insurance

Summary

Planning and field selection should begin a year or two before seeding to ensure that perennial weeds are minimal and a suitable seedbed is available for seeding down forages. The following factors must be considered before establishing a forage stand:

- perennial weed control
- previous residual herbicides
- seed bed preparation
- type of crop stubble if direct seeding
- companion cropping
- species and cultivar selection
- seed quality
- soil fertility
- seeding date
- seeding rate
- weed control

Successful establishment will result in productive forage stands.

FORAGE FERTILITY

Forage Fertility

Forage crops with well established root systems utilize soil nutrients more effectively than annual crops. Optimum forage production is often limited by low soil nutrient levels. Legumes such as alfalfa have the ability to fix atmospheric nitrogen (N), whereas grasses are solely dependent on the addition of nitrogen fertilizer and the breakdown of soil organic matter to supply N requirements. Nitrogen (N), phosphorus (P), potassium (K) and sulphur (S) are the main nutrients needed by forages. In grasses, nitrogen is most often the limiting nutrient contributing to production.

Table 26 shows nutrient removal when harvesting forages. These nutrients are removed in the form of hay, meat or milk. When harvesting hay, the majority of the nutrients are exported from the field, but when the forage is utilized as pasture and grazed, most of the nutrients are recycled back to the soil through the livestock feces and urine. To maintain a high level of production, producers must replace these nutrients, which can easily be done through proper fertilization, using chemical fertilizers or livestock manure.

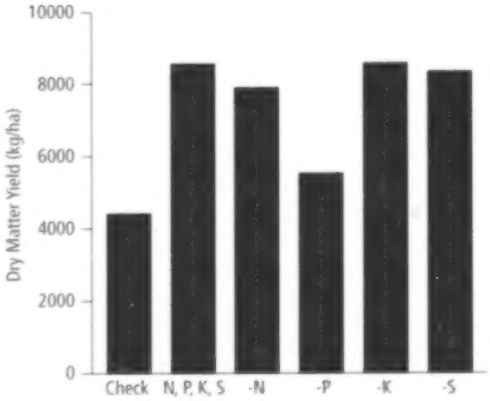
TABLE 26
Soil nutrients removed when harvesting forages in kgs/tonne (lbs/ton) of dry matter harvested[1]

Nutrient	Alfalfa 18% protein[2]	Grass 14% protein[2]
Nitrogen (N)	29 (58)	22 (44)
Phosphorus (P_2O_5)	7 (14)	5 (10)
Potassium (K_2O)	30 (60)	21 (42)
Sulphur (S)	3 (6)	2 (4)

[1] Canadian Fertilizer Institute
[2] Kilograms or pounds of nitrogen = protein in kg (lbs)/6.25

Figure 65 shows the effect of fertilizing a grass-legume mixture. When a complete fertilizer blend containing nitrogen, phosphorus, potassium and sulphur was applied on a legume grass mixture, the yields doubled in relation to the check. A yield increase still occurred as nutrients were removed from the complete fertilizer, which indicates that all nutrients were limiting.

FIGURE 65
Fertilizer effects on legume/grass hay



Notes:

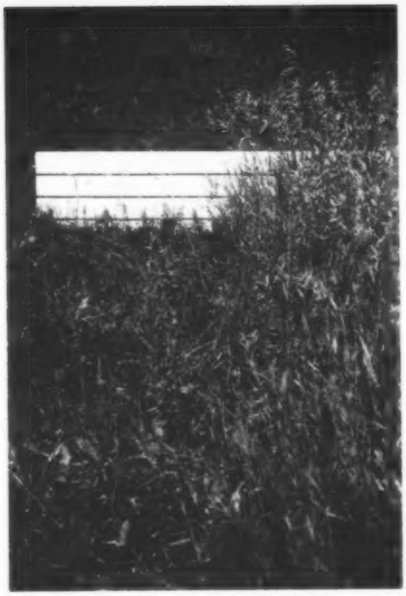
- Alfalfa/timothy hayfield in the Mayerthorpe area of Alberta
- Beginning nutrient levels:
  - undetectable N, 1 ppm P, 223 ppm K, 6 ppm S
- Fertilizer treatment (kg/ha):
  - 100 N (urea), 75 P_2O_5, 88 K_20, 30 S
- Check received no fertilizer, NPKS received all nutrients and the others received all the nutrients except the nutrient indicated i.e. (-N) received P, K, S but no N

Jerome Lickacz – Alberta Agriculture and Rural Development

ALFALFA/GRASS MIXTURE –
NPKS ON LEFT AND NO FERTILIZER ON RIGHT

GRASS PASTURE –
NPKS ON LEFT AND NO FERTILIZER ON RIGHT

ALSIKE CLOVER/GRASS PASTURE –
PKS ON LEFT AND NPKS ON RIGHT



GRASS PASTURE –
PKS ON LEFT AND NPKS ON RIGHT

When the nitrogen was removed from the fertilization, the yields remained high, indicating the alfalfa in the mixture was fixing sufficient atmospheric nitrogen to produce almost the same yield as the complete fertilizer treatment.

Brown and Dark Brown soils in southern and east-central Alberta are often deficient in nitrogen, moderately deficient in phosphorus and less commonly deficient in potassium and sulphur. In central and northern Alberta, on Black, Gray Wooded and Gray Black transition soils, nitrogen and phosphorus deficiencies are common, with occasional deficiencies in potassium and sulphur.

To determine the nutrient levels of the soil and the rate of fertilizers needed, a proper and representative soil sample should be collected from the field and analyzed by a laboratory.

Nitrogen

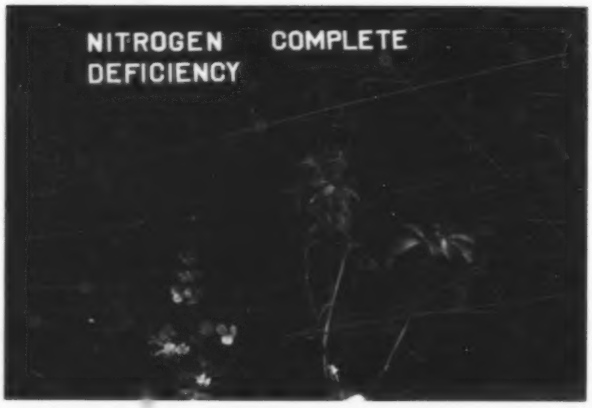
Nitrogen is generally the most limiting nutrient in grass production. To maintain a high level of production in grass stands, producers must apply nitrogen fertilizers. Nitrogen is generally not a limiting factor in legume forage stands if they have been properly inoculated at the time of establishment. Nitrogen is used in plant growth and as a building block for plant proteins. As available nitrogen increases, both forage yield and quality increase.

Most of the nitrogen stored in soil is contained in the organic matter. One per cent organic matter contains about 1,000 kg of nitrogen/ha (1,000 lb of N/ac), but less than 1 per cent per year of this nutrient is released through soil mineralization, which is the microbial breakdown of organic matter. Microbial activity and the rate of nitrogen release from soil organic matter is influenced by environmental conditions, including soil temperature, soil moisture and organic matter content.

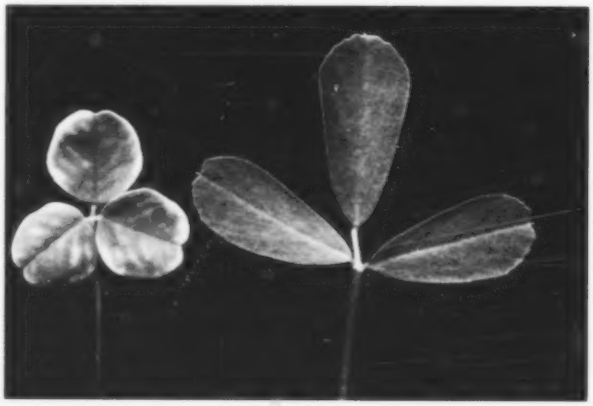
Nitrogen released from soil organic matter decomposition during the growing season supplies only 5 to 20 per cent of the total nitrogen required for grass production. Well aerated soil with higher levels of organic matter will release more plant-available nitrogen, while soils that have low soil organic matter levels will release little plant-available nitrogen. Brown and Gray Wooded soils mineralize the least amount of soil nitrogen.

Symptoms of nitrogen deficiency in plants:

- slow plant growth and plant stunting
- yellow-green leaves or chlorosis - this condition usually begins with the older leaves as nitrogen moves from older leaves to younger leaves when the nutrient is deficient
- leaf tips and margins browning and dying, beginning with the older leaves



NITROGEN DEFICIENCY SYMPTOMS IN ALFALFA (DEFICIENT PLANT ON THE LEFT)



NITROGEN DEFICIENCY SYMPTOMS IN ALFALFA (DEFICIENT LEAF ON THE LEFT)

Grasses

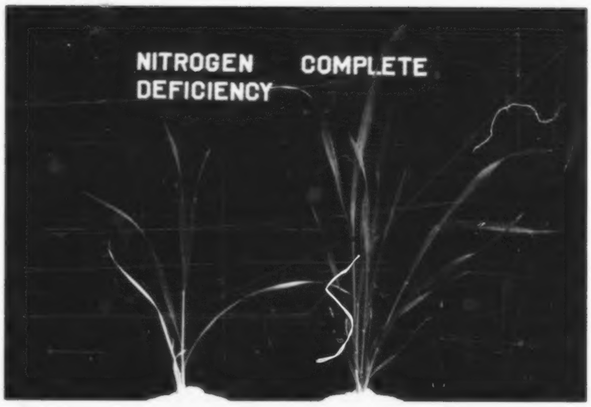
No soils are capable of maintaining a high production of grasses through mineralization (release of N from soil organic matter) alone. Nitrogen fertilization of grasses is necessary to sustain high production. Nitrogen can come from chemical fertilizers, manure or legumes fixing nitrogen when grown in a mixture with grasses. Table 27 shows both the increase in quantity and quality of meadow bromegrass when fertilized with nitrogen.

At modest levels of application, nitrogen mainly increases yield, and as application rates increase, the plants produce larger leaves and more proteins, which increases the quality. The economics of fertilization should be monitored to ensure a return on the cost of fertilizer applied. Precipitation and growing conditions affect the amount of nitrogen needed and used by plants.

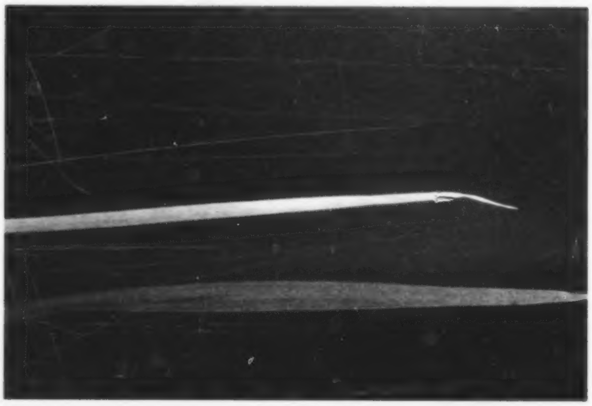
Nitrogen fertilizer should be applied early in the spring before grass begins active growth. A single application of nitrogen fertilizer is recommended in the drier areas where only one hay cut or grazing is taken. In areas where two or more cuts of hay are taken or pastures are grazed two or more times, split applications may be beneficial to yield and extending the grazing system.

If split applications are planned, then approximately 60 per cent of the nitrogen fertilizer should be applied in early spring with the remaining split equally and applied after each cut or grazing. Under irrigation, nitrogen should be applied after each cutting or grazing on grass hay or pastures.

Old grass pastures are sometimes called "sod bound," especially when they consist of creeping or rhizomatous grasses that have been overgrazed and poorly managed, and the soils may be compacted and low in fertility. A soil test will determine nutrient deficiencies. In many cases, nitrogen fertilization and rest or limiting pasture usage will stimulate root and top growth production. Figure 66 shows production increases in a "sod bound" pasture that was fertilized with nitrogen. It may take more than one year for the pasture to be highly productive again. For more information, see the Rejuvenation section of this manual.



NITROGEN DEFICIENCY IN WHEAT (DEFICIENT PLANT ON THE LEFT)



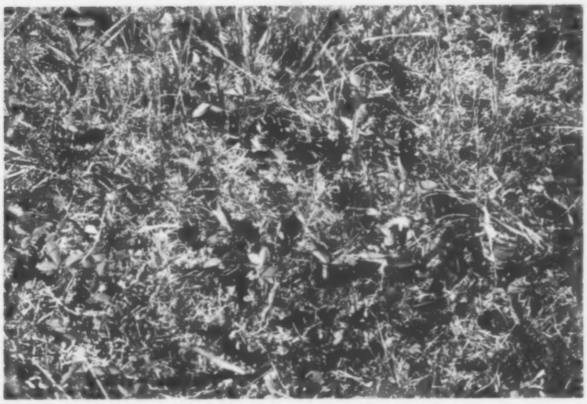
NITROGEN DEFICIENCY SYMPTOMS IN WHEAT WOULD BE SIMILAR TO GRASSES (DEFICIENT LEAF ON TOP)

TABLE 27
Dry matter and protein yields of meadow bromegrass in central Alberta[1]

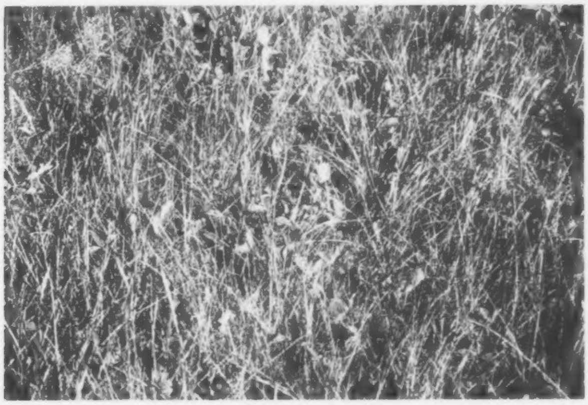
	Levels of N[2] Applied Annually (kg/ha)					
	0	50	100	150	200	300
Dry Matter Yield (kg/ha)	2,280	3,900	5,300	6,130	6,960	7,780
% Crude Protein	11.0	11.6	12.6	13.2	13.8	15.7

[1] average of 2 sites 1988 - 1991
[2] urea nitrogen applied in mid to late April
To convert kg/ha to lb/ac, divide kg/ha by 1.12

Mahli et al. Fertilizer management for forage crops in the Canadian Great Plains, Recent Res. Devel. Crop Sci., 1(2004): 237-271 ISBN: 81-271-0046-3

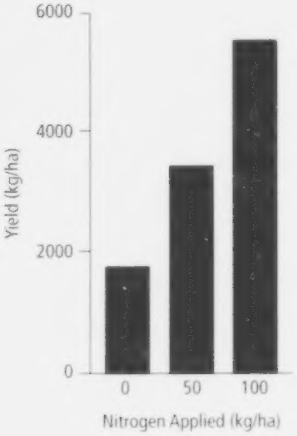


SOD BOUND GRASS PASTURE



SOD BOUND PASTURE RESTED FOR THREE YEARS

FIGURE 66
Effect of nitrogen on dry matter yields of sod bound grass



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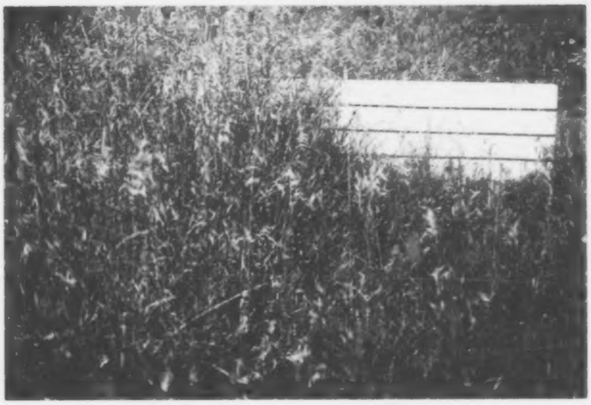


SOD BOUND PASTURE FERTILIZED WITH 100 KG/HA (100 LB/AC) OF NITROGEN ON LEFT AND NO NITROGEN ON THE RIGHT

Legumes

Legumes inoculated with the appropriate rhizobia bacteria are capable of "fixing" nitrogen and meeting most of the nitrogen needs of the plant. As the legume seed germinates and the plant begins to grow, the rhizobia infect the root hairs and form nodules. These nodules are "home" to the bacteria, and they live in a symbiotic partnership with the legume.

NODULES ON ALFALFA ROOTS

The bacteria receive energy in the form of carbohydrates from the host legume and in return, convert atmospheric nitrogen in the soil into a nitrogen form that is useable by the plant. The fixation process follows the plant growth cycle as the amount of nitrogen fixed matches the demand of the plant. The amount of nitrogen "fixed" by the legume is varied and is generally related to the dry matter production of the plant (Table 28). Without rhizobia bacteria, nitrogen fixation will not occur.

TABLE 28
Legume nitrogen fixation in kg N/ha (lb N/ac)*

Legume	Range[1]
Alfalfa	78-222 (70-198)
Cicer Milkvetch	up to 157 (140)
Red Clover	67-129 (60-115)
White Clover	129-202 (115-180)
Bird's Foot Trefoil	50-112 (44-100)
Kura Clover	17-177 (17-158)

*Nitrogen fixation is dependent on effective nodulation, fertility, soil type, soil pH, moisture, growing season, etc. Under good growing conditions, nitrogen fixation would be near the high end of the range.

[1] Heichel (1987; Date and Brockwell (1978); Seguin, et al (2000) - Forage Legumes (2nd Ed) - Univ. of Minnesota

A specific species or strain of rhizobia is required for each legume species (see Establishment section) and must be applied to the seed prior to seeding.

Legume fixation is a very economical method of obtaining nitrogen and may account for up to 80 per cent of the nitrogen required for productive alfalfa fields (Table 29). Available soil nutrients, soil type, soil pH, soil moisture and the length of growing season all affect the amount of nitrogen fixed by the legume. Adding nitrogen fertilizer to legumes may decrease the amount of nitrogen fixed by legumes and cause the legumes to gradually lose the ability to fix nitrogen.

TABLE 29
Nitrogen fixation in inoculated legumes grown in southern Alberta under irrigation

Legume	Plant-N Derived from the Atmosphere* (%)	N Fixed Symbiotically kg/ha (lb/ac)
Alfalfa	80	299 (267)
Sweetclover	90	250 (223)
Fababean	90	299 (267)
Field Pea	80	199 (178)
Lentil	80	150 (134)
Soybean	50	150 (134)
Chickpea	70	121 (108)
Dry Bean	50	69 (62)

*determined by N_{15} isotope techniques

Source: adapted from R.J. Rennie, Agriculture Canada, Lethbridge Research Centre

Several factors influence nodulation and affect the amount of nitrogen the legume is capable of fixing:

- **Effective Nodulation on the Roots**
  If the species-specific live viable rhizobia are correctly applied to the seed, nodules will form on the roots. If the plant is actively growing and the nodules are productive, they will be pink or reddish when cut open. If they are white or greyish, they are not fixing nitrogen.
- **Soil pH**
  Soils in the pH range of 6.6 to 7.5 provide the best conditions for nitrogen fixation. Alfalfa will grow and fix nitrogen in soils down to a pH of ~5.8, but dry matter production is reduced as the soil pH declines. Nitrogen fixation is also reduced as soil pH declines. As pH declines below a pH of 5.8, alfalfa production is substantially reduced. Alsike clover, red clover and birdsfoot trefoil rhizobia are more acid tolerant and tend not to lose production until the pH drops to 5.5. Soils with low pH must be limed to increase soil pH to approximately 6.5 for optimum production.
- **Soil Temperature**
  Legume rhizobia become more active as soils warm up in the spring and summer. Soil temperatures of 25° C are the most favourable for nitrogen fixation by the rhizobia.
- **Soil Fertility**
  Most legumes will fix between 50 per cent and 80 per cent of their total nitrogen requirements (Table 29). Perennial legumes generally fix 75 to 90 per cent of their nitrogen requirements. The balance of the nitrogen requirements are supplied by the breakdown of old stems and leaves, the breakdown of the roots and nodules sloughed off from the previous year's production, the breakdown and mineralization of other organic matter in the soil and from the cycling of nutrients by livestock.

The availability of soil nitrogen will affect the amount of nitrogen fixed. Soil-available nitrogen levels over 35 kg/ha (35 lb/ac) begin to reduce nitrogen fixation. Legumes will generally utilize the available soil nitrogen before the rhizobia begin to fix nitrogen. Insufficient levels of soil nutrients such as phosphorus, potassium or sulphur all affect the rate at which nitrogen is fixed.

Micronutrients also play a part in the fixation process and must be available in adequate supplies. To maximize nitrogen fixation, available soil levels of nutrients should be sufficient to promote good growth. If the legume is growing actively, it will fix nitrogen.

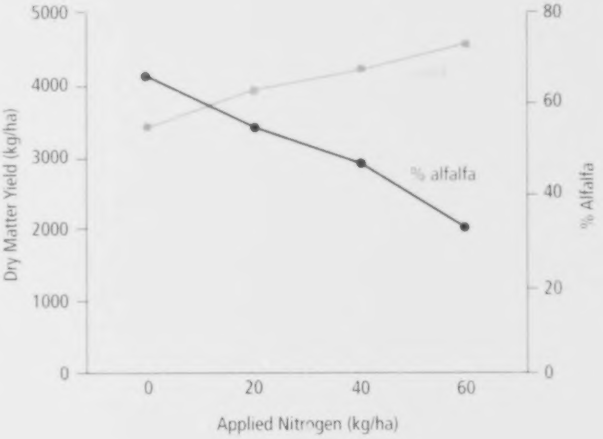
- **Soil Moisture**
  The amount of nitrogen fixed under drought conditions is greatly reduced, which is generally not a problem since the plant growth and subsequent nitrogen needs are reduced under these conditions as well. The plant demand for nitrogen is "fully synchronized" with the rate the rhizobia is capable of fixing the nitrogen. Excess soil moisture such as flooding greatly reduces nitrogen fixation because the amount of air (which contains atmospheric nitrogen) is reduced in waterlogged soils.

Grass-legume Mixtures

When grasses and legumes are grown in mixtures, it is important to apply nitrogen fertilizers based on the grass-to-legume ratio. If high levels of nitrogen are applied to a grass-legume crop, the grass component will increase, reducing the ability of the legume component to be productive and survive in the stand.

Applied nitrogen affects the grass-to-legume ratio in a mixture. This factor is especially important in mixtures with aggressive creeping rooted grasses such as smooth brome grass. Figure 67 shows the alfalfa component in a grass-alfalfa mixture declined from 70 per cent of the mixture with no nitrogen fertilizer to 30 per cent when 60 kg/ha (60 lb/ac) of nitrogen was applied to the mixture. The competition and shading of the grass will affect the ability of the legumes to compete and be productive.

FIGURE 67
Effect of applied nitrogen on yield and per cent legume in a mixed forage stand



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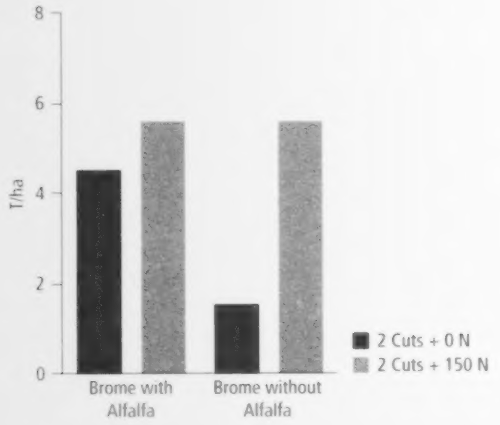
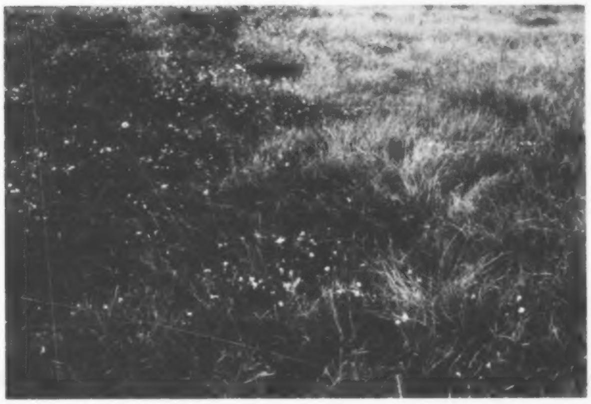
Legumes grown in mixtures with grasses will supply the grasses with nitrogen through cycling of the nitrogen. Figure 68 shows smooth bromegrass yields when grown alone and in an alfalfa mixture. When smooth bromegrass was grown with alfalfa in a 50:50 mixture and no nitrogen was applied, smooth bromegrass yields were 3 times higher than when grown alone and not fertilized. When 150 kg/ha (150 lb/ac) of nitrogen was applied to the mixture, the yield of smooth bromegrass only increased by 24 per cent.

FIGURE 68
Dry matter yield of smooth bromegrass in alfalfa mixtures



N.A. Fairey. Effects of nitrogen fertilizer, cutting frequency and companion legume on herbage production and quality of grasses. Can.J.Pl.Sc. 71:717-725



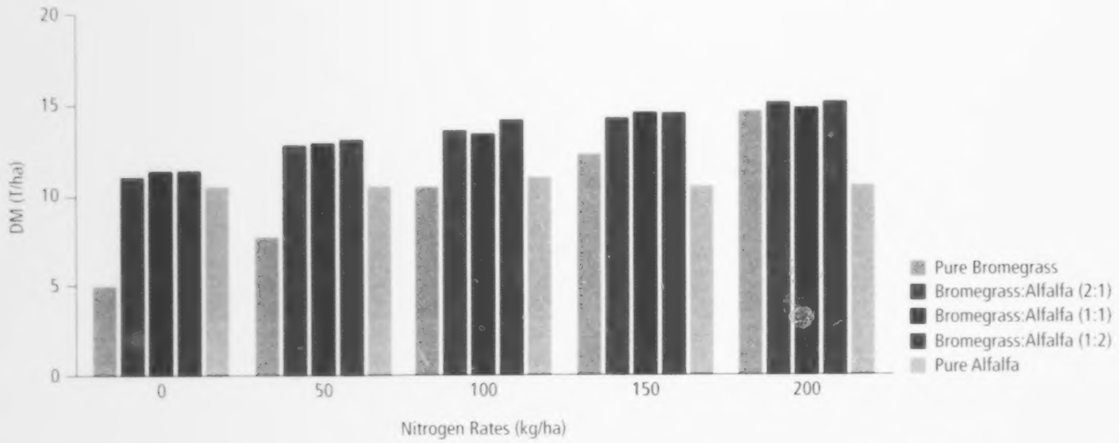
LEGUME/GRASS MIXTURE ON THE LEFT AND GRASS ALONE ON THE RIGHT

Figure 69 shows the yields of different grass-legume ratios using alfalfa and smooth bromegrass. The yields of the bromegrass-alfalfa mixtures were similar for all ratios, and the mixtures were all higher than the smooth bromegrass grown alone. As nitrogen application rates increased, pure smooth bromegrass yields increased, and yields of all mixtures were similar when 200 kg/ha (200 lb/ac) of nitrogen was applied. When no additional nitrogen was applied the mixtures were similar in yield to the pure alfalfa stand.

The addition of nitrogen increased the yields of both the mixtures and the pure stand of bromegrass but did not increase the pure alfalfa stand. This outcome indicates the alfalfa was receiving sufficient nitrogen through fixation and available soil nitrogen to produce maximum growth.

There is no economical benefit to fertilizing mixtures with nitrogen when they contain 40 to 50 per cent alfalfa if the alfalfa is actively fixing nitrogen. There will be sufficient nitrogen cycled within the forage stand to supply the grass with nitrogen.

FIGURE 69
Dry matter yields of smooth bromegrass and alfalfa grown in mixtures at different ratios in central Alberta – 1993-1995 (average of 2 sites)



Mahli et al. Fertilizer management for forage crops in the Canadian Great Plains, Recent Res. Devel. Crop Sci., 1(2004): 237-271
ISBN: 81-271-0046-3

Nitrogen Transfer in Legume/Grass Mixtures

There are two main pathways for the transfer of nitrogen from the legume plant to the grasses when grown in a mixture:

1. Decomposition of plant residue in or on the soil

Stem and leaf decomposition release a large portion of the nitrogen from the legume plant to the neighboring grass plants. Loss of legume stems and leaves in the field during harvesting or grazing, or unutilized fall growth is available for decomposition and subsequent nitrogen transfer. Legumes have high leaf losses from the bottom leaves, which are not accessible to the cattle or have matured and dropped off the stem. Nitrogen leached from the plant material is readily available, but nitrogen from the decomposition may take several years to be available to the grasses. Unharvested grasses will also break down and release nitrogen into the system.

In the fall, most legumes "slough" or shed root hairs and attached nodules, which are broken down the following year and release nitrogen into the cycle. Legume species vary in their sloughing of the nodules. If white clover is shaded or defoliated, it tends to shed its nodules. New nodules are formed as the white clover sends out new stolons. Alfalfa nodules have indeterminate growth and remain attached to the root hairs throughout the growing season, whereas bird's foot trefoil nodules are more determinate and are readily shed after the legume is defoliated. While actively fixing nitrogen, the nodules are very efficient, and very little nitrogen is released or "leaked" into the soil. The total amount of nitrogen made available to other plants while the nodules are actively fixing nitrogen is low.

2. Nutrient cycling of plant material by livestock

All nutrients cycle within a forage stand. Livestock excretions return nutrients back to the soil where they can be broken down and used by the forage plant. Nutrient cycling is higher in pasture systems than in hay systems as most of the top growth is removed from the field in a hay system. In a pasture system, the livestock ingest the plant material and absorb the nutrients needed and excrete the unused nutrients as feces and urine.

Cattle not producing milk will generally utilize 10 to 15 per cent of the nitrogen ingested as protein, and cows producing milk will utilize 20 to 25 per cent. The excess nitrogen is excreted in the form of urine and feces. Urine nitrogen is generally more readily available to the plants than feces nitrogen, which will need to be broken down before being available to the plants. The speed of breakdown and availability will depend on the moisture and fiber content of the feces. Nitrogen losses to the atmosphere are much higher with urine and can be as low as 10 per cent and as high as 40 to 50 per cent, especially in areas where the rate of evapotranspiration is high. Losses depend on environmental conditions. Losses during cool, calm weather are less than during hot, windy conditions.

HIGH FIBER MANURE BREAKS DOWN VERY SLOWLY

MANURE PATCH THAT IS VERY LIQUID WITH LOW FIBER WILL BREAK DOWN QUICKLY

Cattle tend to excrete feces and urine in loitering areas, near water sources, alleyways, trees and in areas grazed more heavily. A grazing management system utilizing high livestock densities in smaller paddocks and quicker rotations will more evenly disperse the manure throughout the pasture.

GRASS GROWTH IN LOITERING AREA UNDER THE TREES

GRASS GROWTH IN THE SAME PASTURE 25 METERS FROM TREES

The use of legume-grass pastures is effective in adding nitrogen to the system if grazing is controlled to allow good distribution of the urine and manure throughout the pasture. Some 30 to 40 per cent legume in a pasture mixture may be sufficient to maintain a productive balance of nitrogen for the grasses.

Phosphorus, potassium and sulphur are all cycled in a pasture situation as well. Animals generally only utilize 10 per cent of these nutrients when ingested. The balance is excreted in the urine and feces.

Nitrogen Sources

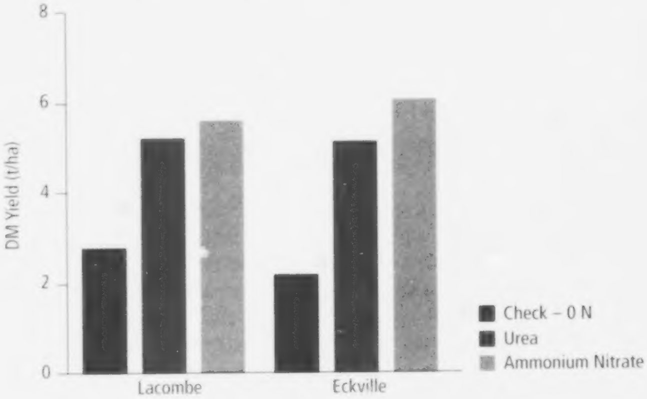
The most commonly used nitrogen fertilizer is urea (46-0-0). Ammonium nitrate (34-0-0) is no longer available in western Canada. When urea is broadcast applied, it is subject to volatilization, which is the gaseous loss of ammonia-nitrogen to the air.

Soil and climatic factors that contribute to increased volatilization include the following:

- < 5-7 mm (1/4") of rainfall soon after application
- soils that are moist on the surface
- warm soil temperatures (> 5° C) and warm air temperatures (>10° C)
- soil pH > 7
- coarse textured soils
- windy conditions
- soils with low organic matter
- high levels of plant residues or litter on the soil surface

In central and northern Alberta, spring temperatures are generally cool, allowing urea to be broadcast in the spring with minimal nitrogen losses (Figure 70). The warmer temperatures and high winds in southern Alberta cause a greater potential for volatilization losses when urea is used. If applied in early spring when soil and air temperatures are still very cool, urea can be used successfully in these areas.

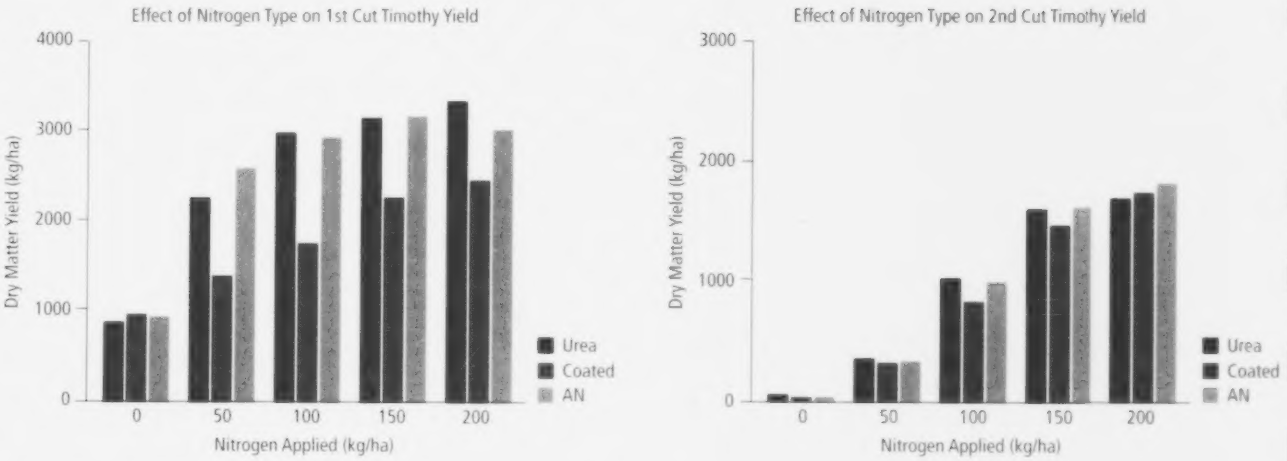
FIGURE 70
Dry matter yield of meadow brome using different nitrogen sources (3 years)



Nitrogen applied at 100kg/ha

Mahli et al. Fertilizer management for forage crops in central Alberta. AAFC bulletin 1993-3E

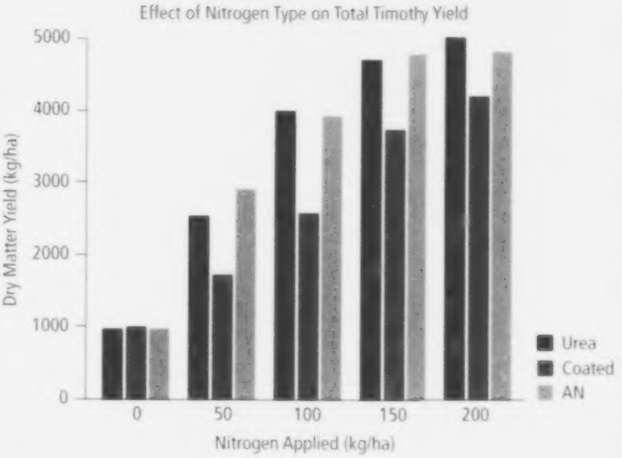
FIGURE 71
Effect of spring-applied urea, polymer-coated urea and ammonium nitrate fertilized at increasing rates on the first cut, second cut and total yields of timothy



Urease inhibitors can be used to treat granular urea to reduce the volatilization losses of nitrogen for about 7 to 14 days. Polymer coated granular urea is another fertilizer product that can be used to reduce volatilization losses of nitrogen, but the nitrogen is released very slowly.

Research in southern Alberta (Figure 71) with broadcast polymer coated granular urea has shown that the urea release is too slow to meet the nitrogen needs of the grass, especially during the period of rapid growth in the spring. Figure 71 shows first-cut yield losses of timothy as high as 40 per cent at the 50 and 100 kg/ha (50 and 100 lb/ac) application rates. At the higher application rates (150 and 200 kg/ha or 150 and 200 lb/ac) of the polymer coated urea, the timothy yields were similar to the lower application rates of the uncoated urea. The second cut of the timothy showed little yield difference between the nitrogen types.

Low temperatures and low soil moisture can delay the release of the nitrogen, which may result in nitrogen deficiencies during the growing season. This delay in nitrogen availability can cause a reduction in yield. The added cost of these products must be considered in relation to the potential volatilization losses of the nitrogen when untreated urea is used.



Coated is polymer-coated urea
AN is ammonium nitrate
Average of Bow Island and Lethbridge sites

R. McKenzie et al. Alberta Agriculture and Rural Development - unpublished

Phosphorus

Phosphorus (P) is a very important nutrient in forage production. Phosphorus is removed from the field at the rate of 5 to 7 kg/T (10-14 lb/ton) of forage dry matter harvested (Table 26). Since legumes can fix their own nitrogen, phosphorus is often the limiting nutrient for optimum legume production. Phosphorus is important in root development and plant growth.

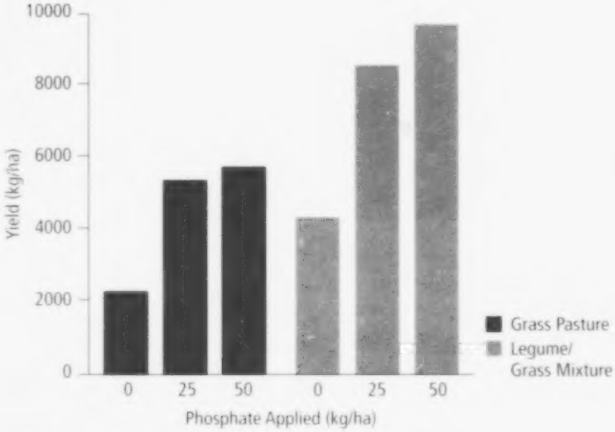
Deficiencies are easily corrected with the addition of phosphorus fertilizers. Phosphorus is not very mobile in the soil and may be applied at high rates, 100 to 200 kg/ha (100 - 200 lb/ac) before seeding for the forage crop to use over several years. An annual application of phosphorus fertilizers on established stands is also an effective method of supplying this nutrient, if soil phosphorus levels are low. This situation may be especially true in stands containing legumes. Figure 72 shows that the addition of 25 kg/ha (25 lb/ac) of phosphorus on both grasses and grass-legume mixtures increased yields substantially.

Soil pH reduces the availability of phosphorous. Soils with pH levels below 6 or above 7.5 may require phosphorous fertilization. Phosphate binds tightly to the clay particles in these soils, making it unavailable to the plants.

Symptoms of forages deficient in phosphorus are difficult to observe, but can include the following:

- stunted, slow growing plants
- blue-green coloration
- purplish undersides of leaves and stems of legumes, beginning with the older leaves
- delayed maturity

FIGURE 72
Effect of annual applications of phosphorus on yield (Mayerthorpe, Alberta, 1997-2000)



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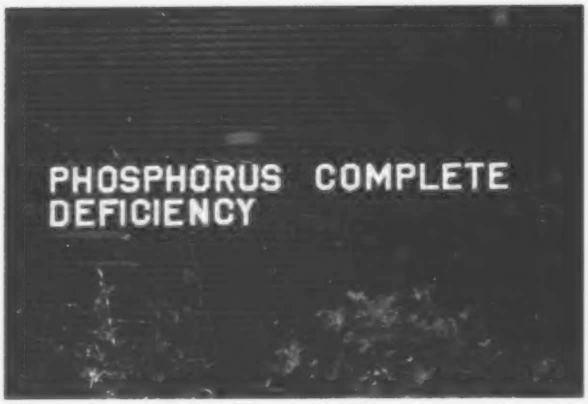
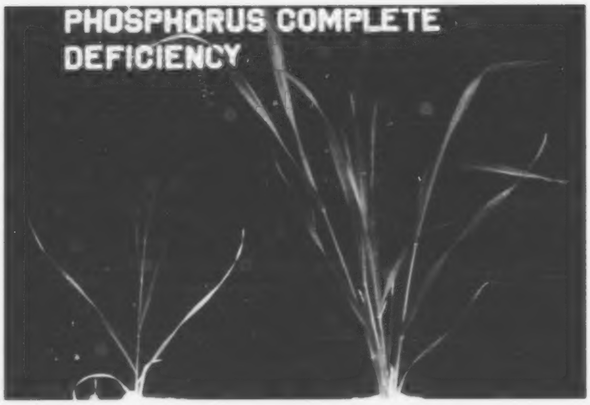
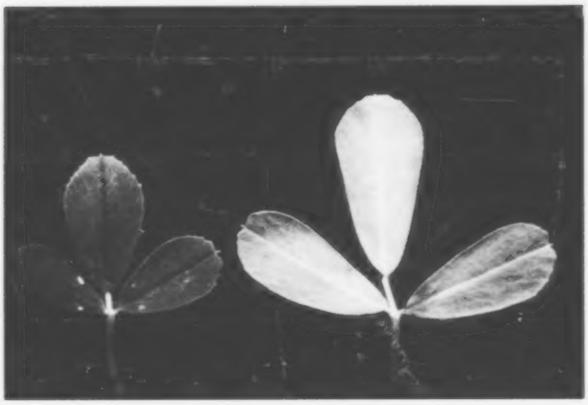
EFFECT OF PHOSPHOROUS ON LEGUME/GRASS MIXTURES – NO PHOSPHOROUS APPLIED ON LEFT AND 25 KG/HA (25 LB/AC) OF PHOSPHORUS APPLIED ON RIGHT


PHOSPHORUS COMPLETE
DEFICIENCY

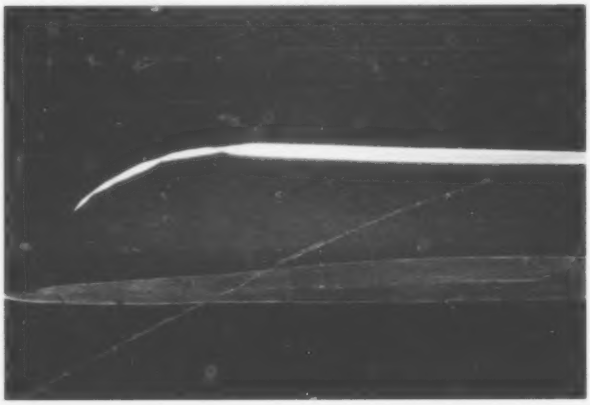
PHOSPHOROUS DEFICIENCY SYMPTOMS IN ALFALFA (DEFICIENT PLANT ON THE LEFT)


PHOSPHORUS COMPLETE
DEFICIENCY

PHOSPHOROUS DEFICIENCY SYMPTOMS IN WHEAT (DEFICIENT PLANT ON THE LEFT)



PHOSPHOROUS DEFICIENCY SYMPTOMS IN ALFALFA (DEFICIENT LEAF ON THE LEFT)



PHOSPHOROUS DEFICIENCY SYMPTOMS IN WHEAT WOULD BE SIMILAR TO GRASSES (DEFICIENT LEAF ON TOP)

Potassium

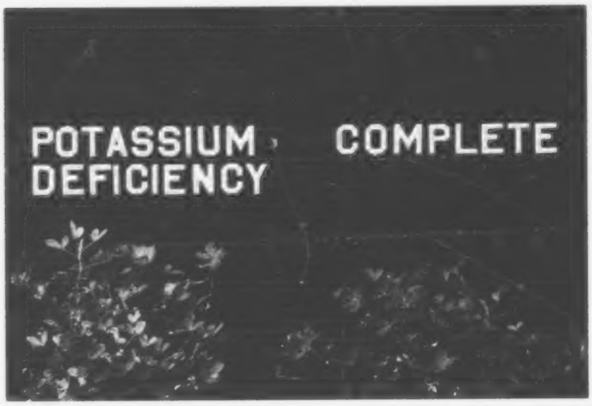
Potassium (K) is a nutrient removed from the field in large quantities when forages are harvested (Table 26). Potassium is important for winter hardiness and winter survival, disease resistance, root development and yield.

Potassium fertilization is normally needed only when soil tests show that soils are low in potassium. When soil test potassium is less than 250 kg of K/ha (250 lb of K/ac) in the 0 to 15 cm (0 - 6 in.) depth, potassium fertilizer should be considered. Most forages are deep rooted and are fairly efficient in taking up soil potassium.

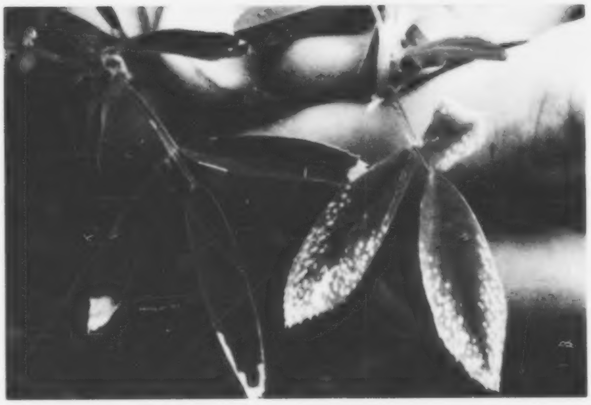
In fields testing deficient in soil K, annual applications of potash fertilizer (K_20) may be necessary. Fields that have sufficient soil K levels will occasionally respond to a 50 lb/ac application of potash fertilizer in early spring, particularly under unseasonably wet, cool weather as these conditions makes soil potassium less available and less mobile in the soil. Many soils do require additional potassium, and a soil test will determine the need to fertilize. Spreading potassium fertilizer on the established forage is an effective way to apply potassium.

Symptoms of forages deficient in potassium:

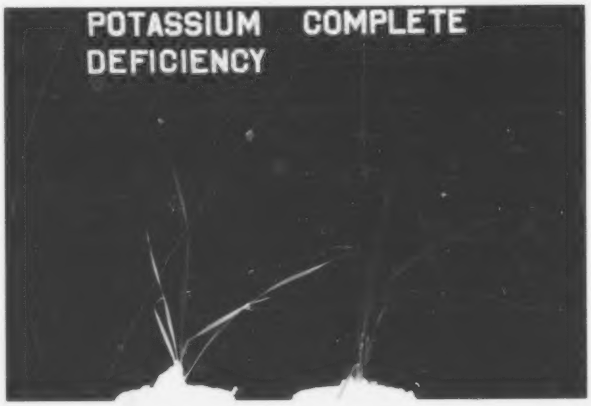
- slow growth
- white spots on leaf tips and margins, generally beginning on older leaves
- weak stems



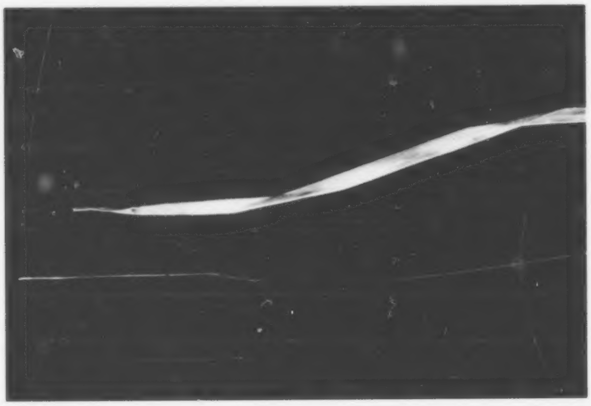
POTASSIUM DEFICIENCY SYMPTOMS IN ALFALFA (DEFICIENT PLANT ON THE LEFT)



POTASSIUM DEFICIENCY SYMPTOMS IN ALFALFA



POTASSIUM DEFICIENCY SYMPTOMS IN WHEAT (DEFICIENT PLANT ON THE LEFT)



POTASSIUM DEFICIENCY SYMPTOMS IN WHEAT WOULD BE SIMILAR TO GRASSES (DEFICIENT LEAF ON TOP)

Sulphur

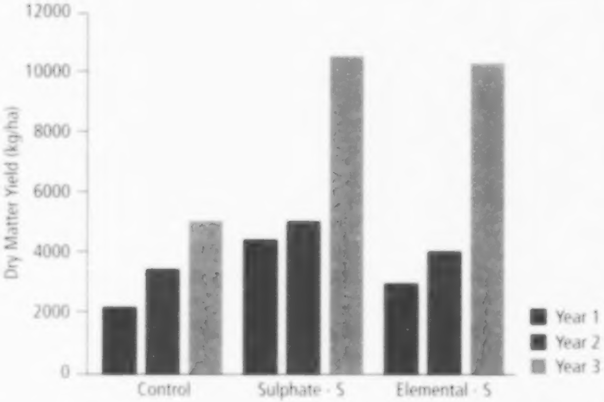
Sulphur is an essential element in forage production and is deficient in many soils in central and northern Alberta on Black and Gray Wooded soils. Sulphur is rarely deficient for forages in southern Alberta on Brown and Dark Brown soils. Soil tests should be used to determine available soil levels. Table 26 indicates sulphur levels removed in forage when harvested. Alfalfa is a high user of sulphur. Sulphur is essential in plant protein formation and legume nodule formation. Soil sulphur availability decreases as soil pH falls below 6.0.

ALFALFA/GRASS MIXTURE –
COMPLETE FERTILIZER (NPKS) WITH SULPHUR ON LEFT
AND NPK WITH NO SULPHUR ON RIGHT

Sulphur fertilizers are available in many forms. Sulphate-sulphur forms are available to the plants in the year of application, whereas elemental sulphur forms may require more than one growing season before they become available.

Research in Central Alberta (Figure 73) shows the effects of sulphate-sulphur and the delayed effect of elemental sulphur when applied annually on grass pastures. The sulphate-sulphur provided a significant increase in yield over the control in year one and increased production in all years. The elemental sulphur showed small yield increases in year one and two compared to the control but by year three, dry matter yields were similar to the sulphate-sulphur treatment.

FIGURE 73
Effects of fertilizing grass with sulphate – S and elemental – S over a 3-year period in central Alberta



Sulphur applied annually at 20 kg/ha, nitrogen applied to all plots at 100 kg/ha in year 1 and 2 and 200 kg/ha in year 3. Grass was a smooth bromegrass and kentucky bluegrass mixture.

Mahli et al – Effectiveness of elemental S fertilizers on forage grass. Cdn. J. of Plant Sc. Vol. 80 p 105 - 112

Broadcast elemental sulphur is slow to break down into a form readily available to perennial forages and should only be used in a long-term fertility program. Temperature, moisture and oxidizing bacteria in the soil all contribute to the breakdown of elemental sulphur into the sulphate form.

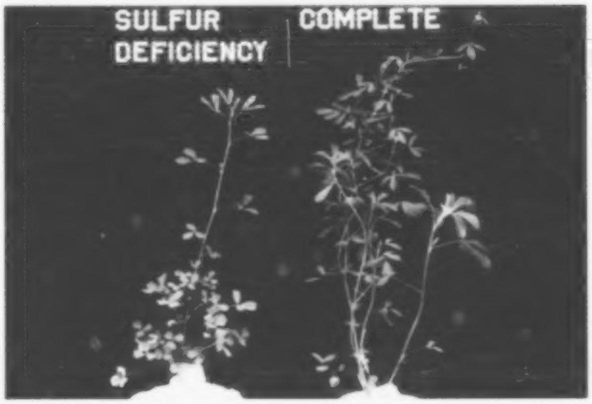
Sulphur levels are usually adequate to high in the Brown and Dark Brown soil zones, but are frequently deficient in the Black and Gray Wooded soils. Much of the sulphur in the topsoil is contained in the soil organic matter and is slowly released as sulphate-sulphur (SO_4-S), the form that crops readily take up. Sulphate-sulphur is similar to nitrate-nitrogen, in that it is mobile in soil and subject to leaching, particularly in sandy soils.

For irrigation farmers, irrigation water naturally contains sulphate-sulphur. Although amounts in irrigation water vary over time, approximately 30 kg/ha (27 lb/ac) of sulphate-sulphur is added to the soil in 30 cm (12 in.) of irrigation water. Therefore, sulphur fertilizer is rarely required on irrigated lands.

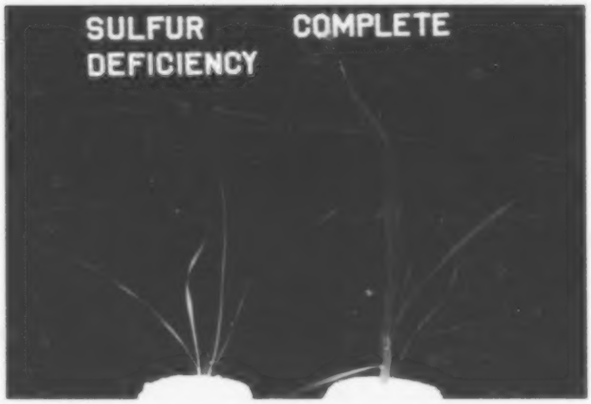
Fertilizers containing sulphate-sulphur, such as ammonium sulphate (21-0-0-24), which contains 24 per cent SO_4-S, are very effective if soils are deficient in sulphur.

Symptoms of forages deficient in sulphur:

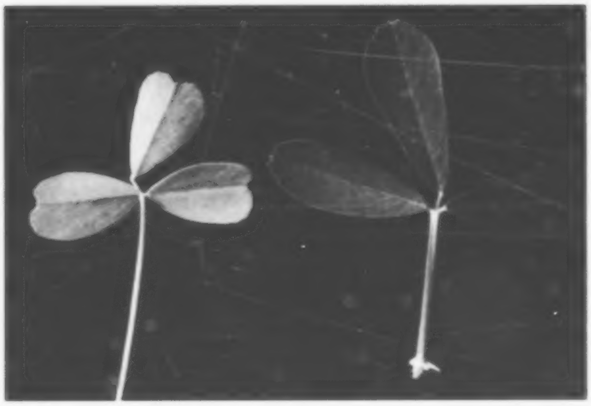
- slow growth
- small weak plants
- newer leaves light green to yellow


SULFUR DEFICIENCY
COMPLETE

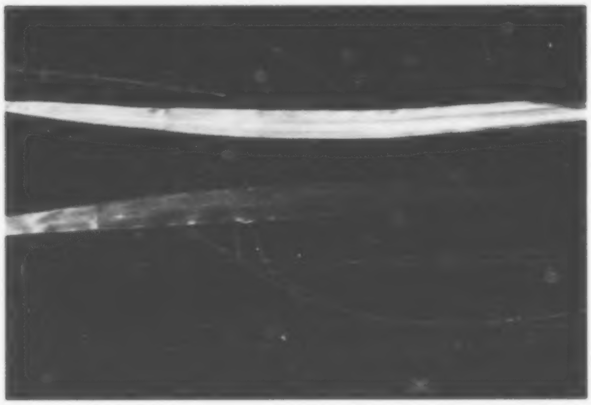
SULPHUR DEFICIENCY SYMPTOMS IN ALFALFA
(DEFICIENT PLANT ON THE LEFT)


SULFUR DEFICIENCY
COMPLETE

SULPHUR DEFICIENCY SYMPTOMS IN WHEAT
(DEFICIENT PLANT ON THE LEFT)



SULPHUR DEFICIENCY SYMPTOMS IN ALFALFA
(DEFICIENT LEAF ON THE LEFT)



SULPHUR DEFICIENCY SYMPTOMS IN WHEAT WOULD BE
SIMILAR TO GRASSES (DEFICIENT LEAF ON TOP)

Micronutrients

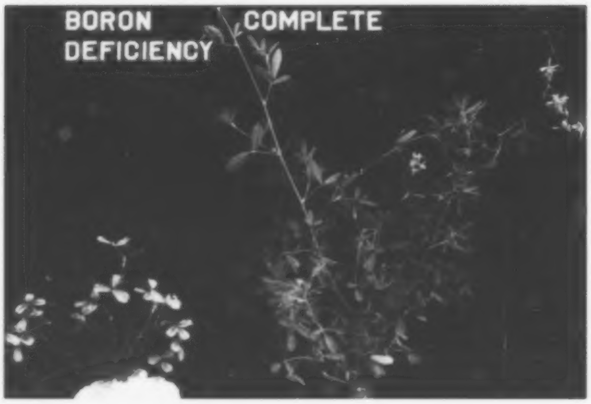
Boron, copper, zinc, chlorine, iron, manganese, molybdenum and other minerals are micronutrients required by forage crops. While Alberta soils generally contain adequate amounts of micronutrients, some deficiencies may occur in some soils.

The parent material from which the soil developed and soil forming processes determine the inorganic micronutrient content of the soil. As minerals break down, micronutrients are gradually released in a form available to plants. Two sources of readily available micronutrients exist in soil: nutrients that are adsorbed onto soil colloids (very small soil particles) and nutrients that are in the form of salts dissolved in the soil solution.

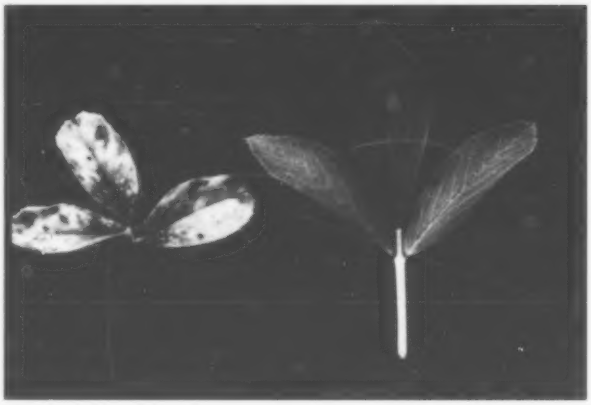
Organic matter also contains micronutrients. Most micronutrients are held tightly in complex organic compounds and may not be readily available to plants. However, the compounds can be an important source of micronutrients when they are slowly released into a plant-available form as organic matter decomposes.

Intensive cropped, sandy soils (course texture) are the most likely to be low in micronutrients. Clay soils (fine texture) are less likely to be low in plant-available micronutrients. Cool, wet soils reduce the rate and amount of micronutrients that may be taken up by crops. Micronutrient deficiencies in the spring may be short lived, and as soils warm during the growing season, micronutrient deficiencies may disappear.

Soil and tissue tests should be used to determine micronutrient levels present in the soil and plants. Deficiencies are generally only in patches in the field, which makes it difficult to detect when using only soil tests. These nutrients are only needed in small quantities and applying too much may create toxic levels that may be difficult to correct. Generally, when these nutrients are needed, they are mixed with other fertilizers to prevent excess application.



BORON DEFICIENCY SYMPTOMS IN ALFALFA (DEFICIENT PLANT ON THE LEFT)



BORON DEFICIENCY SYMPTOMS IN ALFALFA (DEFICIENT LEAF ON THE LEFT)

Manure as a Nutrient Source

Manure is a very good source of nutrients for perennial crops. Nitrogen, phosphorus, potassium and sulphur are available in manure in varying amounts. The amount of nutrients in the manure will depend on the source of the manure (dairy, hog, feedlot, etc.), the moisture content of the manure, the feed being fed to the livestock, the amount and type of bedding used for the livestock and the storage system used for the manure. These factors will also affect the amount and availability of the nutrients in the manure (Table 30). Manure testing is necessary to determine the actual nutrient analysis of the manure, which will help determine the rate of manure application.

The total nitrogen in the manure includes inorganic nitrogen (ammonium and nitrate), which is readily available to the plants, and organic nitrogen, which is not immediately available to the plants. The organic nitrogen must mineralize or break down into inorganic nitrogen before the plants can use it. After manure application, this process will begin to occur, and there will be some breakdown in the year of application. In Table 30 "crop nitrogen" refers to readily available nitrogen and mineralized organic nitrogen, which can be utilized by the crop in the application year minus the expected nitrogen losses due to volatilization.

The phosphorus in manure is mostly available to the crop in the year of application. Manure applications to meet the nitrogen needs of perennial grasses will provide sufficient phosphorus for several years. Continued manure applications to meet the nitrogen needs may create high levels of phosphorus in the soil, which may cause environmental problems if allowed to runoff or erode into nearby water bodies.

Potassium in the manure is available to the plants in the year of application. Applying high levels of manure to meet nitrogen needs may lead to high potassium concentrations in the forage. Plants will take up higher levels of potassium than is needed for production if soil concentrations are too high. High concentrations of potassium in forages can cause health problems in livestock.

Other nutrients such as sulphur, calcium and many micronutrients such as boron, copper, etc. are present in manure. The concentrations of these nutrients are quite variable and depend on the diets fed to the livestock producing the manure.

COMPOSTED FEEDLOT MANURE

APPLYING COMPOSTED MANURE

Composted manure is an excellent source of nutrients. Phosphorus, potassium and sulphur concentrations in composted manure are greater than uncomposted manure. During the composting, nutrient concentrations increase as there is a volume reduction when raw manure is composted. There is some loss of nitrogen during the composting as ammonia is volatilized into the atmosphere.

Manure can be applied to perennial forages by broadcasting or injection. Liquid manure that is injected will have fewer nutrient losses from volatilization and runoff, but it requires more specialized equipment, is more expensive to apply and may damage the forage stand.

TABLE 30
Standard values for manure nutrient content and estimated daily manure production

Species/Class	Typical Nutrient Content (% of fresh manure)					
	Moisture[1]	Total N[1]	Available N	Crop N	Total P[2]	Total K[3,4]
Beef						
Feeders Finishers Feeder calves Cow/calf pair Cows/bulls	50 (30-70)	1.00 (0.65-1.25)	0.26	0.32	0.24	0.67
Paved Feedlot	65 (50-75)	0.70 (0.45-0.80)	0.27	0.25	0.09	0.38
Dairy						
Free-stall housing	92 (85-95)	0.40 (0.35-0.60)	0.18	0.17	0.09	0.42
Tie-stall housing Loose housed Replacements Calves	80 (70-85)	0.50 (0.45-0.65)	0.21	0.19	0.09	0.42
Swine						
Liquid	96 (90-99)	0.35 (0.20-0.55)	0.16	0.16	0.11	0.17
Solid	50 (40-70)	0.80 (0.60-0.90)	0.32	0.31	0.15	0.23
Poultry						
Caged layers, belt removal (solid)	40 (30-60)	3.01 (2.50-3.50)	2.01	1.89	1.54	1.00
Caged layers, deep pit (solid)	50 (30-60)	2.41 (2.00-3.00)	1.60	1.51	1.23	0.83
Caged layers (liquid)	90 (85-95)	0.60 (0.50-1.00)	0.40	0.38	0.25	0.20
Broilers replacement pullets	35 (30-50)	3.41 (3.50-4.00)	1.95	1.84	0.95	1.00
Broiler breeders	35 (30-50)	3.01 (1.60-2.10)	1.72	1.63	0.95	1.00
Turkey breeders	35 (30-50)	1.75 (1.50-2.00)	1.00	0.95	0.59	0.63
Sheep						
Ewes w/lambs Ewes/rams Feeders	50 (30-65)	1.00 (0.62-1.25)	0.40	0.36	0.20	1.04
Lambs	50 (30-65)	0.70 (0.50-1.00)	0.28	0.25	0.20	1.04
Goats						
Goats	50 (30-65)	0.63 (0.50-0.75)	0.25	0.23	0.23	1.04
Horses						
Feedlot	50 (30-60)	1.50 (1.00-2.00)	0.75	0.71	0.23	1.04
PMU	75 (50-80)	0.60 (0.50-0.70)	0.30	0.29	0.13	0.50
Donkeys Mules	50 (30-70)	1.00 (0.80-1.10)	0.50	0.48	0.23	1.04

TABLE 30 (continued)
Standard values for manure nutrient content and estimated daily manure production

Species/Class	Nutrient[1] (% of fresh manure, except $NH_4 - N$)				
	Moisture	**Total N**	**$NH_4 - N^5$**	**Total P**	**Total K**
Liquid swine	96.6 (91.0-99.0)	0.31 (0.04-0.68)	1946 (230-5,150)	0.10 (0.00-0.51)	0.14 (0.03-0.37)
Liquid dairy	91.1 (80.1-99.0)	0.34 (0.07-0.76)	1463 (21-7,168)	0.09 (0.01-0.85)	0.32 (0.02-0.98)
Solid beef	74.6 (61.6-79.9)	0.60 (0.14-2.02)	564 (11-2,656)	0.14 (0.03-0.64)	0.59 (0.16-2.54)
Liquid poultry	90.9 (81.3-97.4)	0.80 (0.30-1.42)	5751 (107-10,510)	0.28 (0.06-0.51)	0.33 (0.16-0.53)

[1] Figure presented is average content, with observed range in values in brackets

[2] To convert to P_2O_5, multiply number in table by 2.29

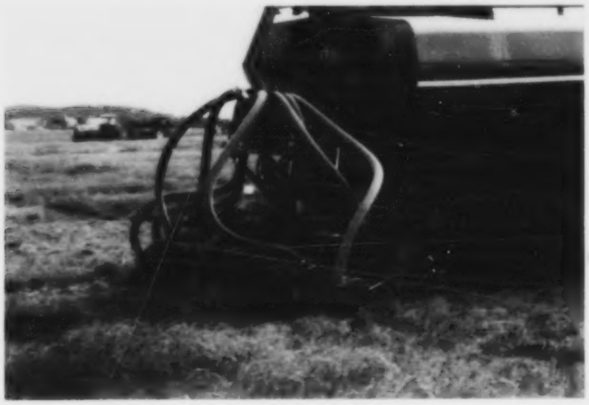
[3] To convert to K_2O, multiply number in table by 1.20

[4] From the 2000 Code of Practice for Responsible Livestock Development and Manure Management (AF 2000)

[5] NH_4 - N expressed in parts per million (ppm)

Source: Nutrient Management Planning Guide, 2007, Alberta Agriculture and Food

Broadcasting manure on forages should be done during plant dormancy or after a harvest or grazing to prevent contaminating the forage. Liquid manure will "soil" the forage stand if applied to an actively growing crop. This situation may create health problems for the livestock as well as ensiling problems if the forage is ensiled. Livestock may refuse to graze the plants if they are tainted with manure. When broadcasting drier manure, care must be taken to ensure that manure clumps are broken up to prevent smothering plants.



LIQUID MANURE APPLICATOR

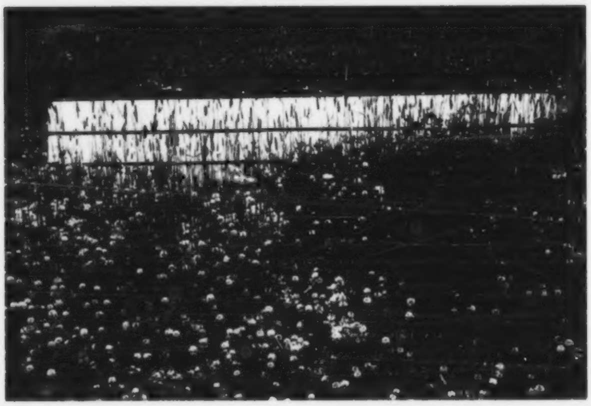
LIQUID MANURE APPLIED TO GRASS PASTURE

Problem Soils

Many soil conditions will affect forage production, some of which can be corrected with additives and some that can only be maintained through good forage management.

Low soil pH and salinity cause problems in forage production in Alberta. Proper species selection is important in problem soils. Some forage species are more productive in soils with a low pH or high salinity than others (see adaptation, Table 1 and the species sections). For example, alfalfa production begins to decrease as the soil pH level drops below pH 6 whereas red, alsike and white clovers, timothy, Kentucky bluegrass, fescues and others have good tolerance to acidity.

APPLICATION OF WOOD ASH ON RIGHT AS A LIME SOURCE ON ALFALFA/GRASS MIXTURE



APPLICATION OF WOOD ASH ON RIGHT AS A LIME SOURCE ON LEGUME/GRASS MIXTURE. ALSIKE CLOVER HAS MORE ACID TOLERANCE AND IS THE PREDOMINATE LEGUME ON THE LEFT, AND AFTER THE APPLICATION OF WOOD ASH, ALFALFA IS THE MORE PREDOMINATE LEGUME ON THE RIGHT

Soils that have been fertilized with high rates of acid-forming fertilizers over long periods, the Gray Wooded soils and peat soils are the most likely to have low pH. These conditions can be corrected using liming materials such as limestone, marl or wood ash. A lime requirement soil test will indicate levels of liming materials needed to be effective. Application rates will depend on soil type, soil pH and liming materials used.

Salinity is the result of soil salts having been brought to the soil surface by the soil moisture. As the soil moisture evaporates, it leaves the salts behind, creating a high concentration of soluble salts in the root zone. These salts can accumulate in the soil at levels that severely affect plant growth.

Soil tests can determine the electrical conductivity (EC), which is the amount of electrical current a soil extract will conduct and is directly related to salt content. Electrical conductivity is measured in dS/m (deciSiemens/metre). Soils having an EC greater than 4 dS/m are considered saline although soils having an EC of 2 (slightly saline) at the soil surface may affect alfalfa establishment. Some forage species have more tolerance to salinity than others. The wheatgrasses, for example, tend to be more tolerant to salinity than crops such as timothy (see adaptation, Table 1).

Forages can be utilized to manage and prevent salinity problems in the soil. Growing deep-rooted forages such as alfalfa, which will tolerate some salinity once established, in saline seeps and discharge areas will reduce salt build-up in the rooting zone of shallower rooted plants.

Soil Sampling

To determine the nutrients needed, forage crop fields should be soil sampled and analyzed for actual soil nutrient levels. Fields and pastures should be sampled to the 0 to 15 cm (0 - 6 in.) and the 15 to 30 cm (6 - 12 in.) depths and analyzed separately. In some cases it may be beneficial to sample the 30 to 60 cm (12 - 24 in.) depths.

When fields are sampled, the samples should be taken randomly throughout the field and should be representative of the soil in the field. Problem areas and areas not representative of the majority of the field should be sampled separately to determine specific problems and solutions for these areas.

To obtain a good representative sample of the field, 15 to 20 samples should be collected. The samples should be combined, thoroughly mixed and a sub-sample taken from the composite sample and air dried to prevent nitrate changes. Contact the company or laboratory doing the analysis to determine handling, packaging and information needed for the analysis. A properly obtained soil analysis will identify nutrients needed and potential soil problems.

Guide to Fertilizer Use on Hay and Pasture Crops

A general guide to fertilizer use on grasses and legumes on the different soil types can be found in Table 31. The rates in the table include present soil levels plus added nitrogen, phosphorus, potassium or sulphur to give the total nutrient levels needed for each soil type. Differences in soil nutrient levels, soil moisture conditions, level of production required and most importantly, the economics of higher production will all have a bearing on the levels of fertility applied.

It is recommended that soil tests be used to determine deficiencies of nitrogen, phosphorus, potassium and sulphur and to identify other soil characteristics such as acidity and salinity that affect forage yields and fertilizer response. Factors such as rainfall or soil moisture, which affect forage crop growth, will affect the level of nutrients applied. In the Brown and Dark Brown soil areas where production is limited by rainfall, lower levels of nutrients, especially nitrogen, are needed.

Table 31 shows the approximate amounts in kg/ha of nitrogen (N), phosphate (P_20_5), and sulphur (S) required by various crops for five soil areas in Alberta. Potash (K_20) is recommended only when a soil chemical analyses indicates a deficiency.

Example
If smooth bromegrass is grown in the Black soil zones and an average production of 6 tonnes/ha (2.7 tons/ac) is desired, the following fertility levels will be needed.

Table 26 indicates that 1 tonne of grass utilizes:

- nitrogen – 22 kg/tonne (44 lb/ton)
- phosphorus – 5 kg/tonne (10 lb/ton)
- potassium – 21 kg/tonne (42 lb/ton)
- sulphur – 2 kg/tonne (4 lb/ton)

When harvested, this crop of smooth bromegrass would remove:

- nitrogen – 132 kg/ha (119 lb/acre)
- phosphorus – 30 kg/ha (27 lb/ac)
- potassium – 126 kg/ha (113 lb/ac)
- sulphur – 12 kg/ha (11 lb/ac)

To ensure a smooth bromegrass forage yield of 6 tonnes/ha (2.7 tons/ac), soil nutrient availability plus added fertility should contain the above or higher levels of N, P, K and S.

Fertilizing legume mixtures with nitrogen must be evaluated to determine the economical benefit when they contain 40 to 50 per cent alfalfa if the alfalfa is actively fixing nitrogen. In an intensively managed pasture that distributes the manure evenly throughout the pasture, alfalfa levels of 30 per cent may be sufficient to maintain the grasses in the mixture.

Forage mixtures with less than 40 per cent legume can be fertilized with nitrogen at rates based on the ratio of legume in the mixture. Example: If the mixture contains 25 per cent alfalfa and 75 per cent grass, the mixture should be fertilized using 75 per cent of the required amount of nitrogen.

Example
75% grass: 25% alfalfa
If 100 kg/ha (100 lb/ac) of nitrogen is required based on soil sampling, then 75% of 100 kg/ha (100 lb/ac) nitrogen = 75 kg/ha (75 lb/ac) of nitrogen should be applied

The economics of fertilizing all forage crops and the application rates should be evaluated to determine the cost and benefits of this practice.

TABLE 31
General fertility guidelines for forages[1] in the soil climatic areas of Alberta (kg/ha of nutrient)

Soil Type	Forage	Nitrogen	Phosphate (P_2O_5)	Potash (K_2O)	Sulphur
Irrigation					
	Grass	200	0 - 60	0 - 180	0 - 20
	Legume	0	0 - 60	0 - 250	0 - 30
Brown					
	Grass	70	0 - 35	0 - 70	0 - 10
	Legume	0	0 - 35	0 - 90	0 - 15
Dark Brown					
	Grass	80	0 - 40	0 - 70	0 - 10
	Legume	0	0 - 40	0 - 90	0 - 15
Black					
	Grass	120	0 - 50	0 - 160	0 - 20
	Legume	0	0 - 50	0 - 240	0 - 30
Gray Wooded					
	Grass	110	0 - 45	0 - 160	0 - 20
	Legume	0	0 - 45	0 - 240	0 - 30

[1] Nitrogen, phosphorus, potassium and sulphur fertility requirements include soil levels based on a soil test plus additional nutrients applied through fertilization or manure application.

Notes
Potash (K_2O) is only recommended when soil tests indicate a deficiency.
Grass-legume mixtures containing more than 40% legume may not require additional nitrogen applications.
The response to the fertility levels applied will be dependent on soil moisture conditions.
The economics of adding nutrients must be evaluated.
To convert kg/ha to lb/ac, divide kg/ha by 1.12

TAME PASTURE MANAGEMENT

Tame Pasture Management

Pasture management is the management of forage-livestock systems. Forage-livestock systems are a complex integration of animal, plant, soil, environmental and human components that together form an integrated ecosystem. With all these components and interactions, pasture management can be a complex issue. Four pasture management principles are as follows:

1. Match forage species to the soil and the environment.
2. Minimize nutrient and water loss, and prevent deterioration of soil and water.
3. Match forage quality and quantity to animal needs.
4. Match grazing method to plant, animal and management needs.

Pasture managers need to balance forage production with forage consumption and animal requirements. Pasture shortages and forage wastage are expensive. Management must be both profitable and ecologically sustainable. Management practices affect pasture and animal productivity. Forage species selection, livestock type, soil fertility, timing of grazing and rest periods, paddock size and grazing method decisions all affect pasture profitability and sustainability. These factors make up a pasture management system that is unique for each individual operation.

Match Forage Species to the Soil and Environment

Forage species need to be adapted to the pasture site for maximum production. Select forage species that will survive and be productive in the pasture soil and environment. Consider winter hardiness, length of growing season, drought tolerance, flooding tolerance, soil pH and salt tolerance. Forage species also need to be adapted to the grazing method selected. Well adapted, long-lived, productive, palatable forage species reduce pasture costs.

Forage species have different life spans. Some are long lived and fit well into permanent pastures. Others have shorter life spans and are best for quick ground cover and short-term forage. Winter hardiness and drought tolerance also affect species life span. Selected species must be adapted to local growing conditions for long-term productivity.

Finally, forage species need to be adapted to the grazing method used on the pasture (Table 32). Some species grow slowly and require infrequent use followed by long rest periods. Other species grow rapidly and work well in intensively managed grazing methods.

TABLE 32
Rest requirement and rate of regrowth for selected forage species

Long Rest, Slow Regrowth	Moderate Rest and Regrowth	Short Rest, Rapid Regrowth
Timothy	Reed Canarygrass	Orchardgrass
Crested Wheatgrass	Alfalfa	Tall Fescue
Russian Wildrye	Sainfoin	Kentucky Bluegrass
Altai Wildrye	Alsike Clover	Meadow Bromegrass
Smooth Bromegrass	Red Clover	Perennial Ryegrass
Intermediate Wheatgrass	Sweetclover	Italian Ryegrass
Pubescent Wheatgrass		Meadow Foxtail
Western Wheatgrass		White Clover
Northern Wheatgrass		Creeping Red Fescue
Cicer Milkvetch		

Plant Population

While productive forage species are important for good pasture production, it is just as important to have enough plants present. To maximize forage production, plants need to capture and use as much of the sun's energy as possible. Bare ground also provides an opportunity for weed invasion. Appropriate plant density on a pasture varies with plant species and environment. Bunch grasses are often spaced farther apart than creeping rooted plants, which tend to fill in between rows more quickly. Plants tend to be spaced more widely apart in dry environments than wet areas.

Table 33 lists minimum seedling density recommendations for the first year after seeding to obtain a productive stand. Plant density may decline further in following years. However, ground cover should improve. Stands of bunch grasses and legumes will get thicker as plant crowns get larger. Stands of creeping rooted plants thicken quickly by rhizome proliferation.

TABLE 33
Suggested seedling density (plants/m^2) for the first year after seeding to obtain a productive stand

Soil Zone	Legumes	Grass/Legume (50:50)	Grass
Black	80 - 100	80 - 100	100 - 160
Dark Brown	60 - 100	60 - 100	100 - 160
Brown	30 - 50	20 - 40	20 - 40
Gray Wooded	40 - 50	30 - 40	40 - 50
Irrigation	150 - 250	150 - 200	200 - 300

To convert plants/m^2 to plants/ft^2, divide by 10.80.

Seedling density in the moist areas of the Gray Wooded soil zone should be similar to those of the Black soil zones.

Source: Perennial Forage Establishment in Alberta, Agdex 120/22-3, Alberta Agriculture and Rural Development

Mixtures vs. Monocultures

Pastures can be seeded to a mixture of forage species or to only one species (a monoculture). Monocultures tend to be more susceptible to extreme variations in weather and management and may be less flexible. They may also be easier to manage. Mixtures of several species with a variety of traits can give a more flexible forage supply and reduce risk, but may be harder to manage. Good mixtures take advantage of variability in climatic and soil conditions.

Considerations for forage mixtures:

- better adaptation to fields with diverse topography, soil types and salinity levels
- forage production may be more consistent through the growing season because different species have peak production at different times; however, differences in peak production periods may make pasture management more difficult
- diverse rooting patterns make more efficient use of soil moisture and nutrients
- adapted species replace species less suited to soil conditions, climate or management over time
- less susceptible to insects and diseases
- legumes mixed with grasses have the potential to supply grasses with nitrogen

Considerations for forage monocultures:

- easier to seed, establish and manage for grazing
- more options for weed control
- more uniform palatability reduces selective grazing
- uniform forage growth and regrowth
- more stable plant composition with no competition from other species
- more predictable production cycle
- easier to graze plants at the optimum growth stage
- only one species may be adapted to the site or intended use

Good pasture mixtures should make pasture management easier. Poor mixtures make management more difficult. The most compatible species are those that minimize plant competition within the mixture, so the best characteristics of all species are realized. Mixtures should combine forage species with similar production periods, maturities and palatabilities. Species that mature at different times or have different palatabilities create management problems. Species like meadow foxtail and crested wheatgrass mature earlier than many other forage species, and their palatability decreases rapidly as they mature. In a mixture, these species are ready to graze before other species. Pastures either have to be grazed early, harming later maturing species, or grazed later to protect the late maturing species but with reduced use of early species. Forage species in mixtures should be compatible with each other.

Many forage species are adapted to moist, fertile pastures, so it is relatively easy to make up mixtures for these sites. The more extreme the site conditions (soil moisture, soil pH, salinity, length of growing season), the fewer available options and the better simple mixtures or monocultures work. Including a wide variety of forage species on these sites, hoping they will find their own niches, is often expensive and may make pasture management more complicated.

Rather than planting a diverse seed mixture throughout, keep individual pasture mixtures simple and have a variety of pastures planted to different species. This approach can be very effective for managing forage production and risk in areas where plant species are less compatible with each other and need different management.

Pasture mixtures should include a well adapted, high producing forage grass and a legume wherever possible. Including legumes improves forage yield, forage quality and soil nutrient levels. A sod-forming or creeping rooted forage grass may also be added to protect the soil.

Species selection is important when establishing a new pasture. However, on established pastures, working with existing plants may be more economical than re-seeding, which can be expensive. Similar improvements to forage production often come from other management changes for substantially less expense. According to a study by Clark, Buchanan-Smith and Weise, climate and especially seasonal rainfall, rather than species, determines at least 60 per cent of forage productivity on pastures. Management has a huge effect on pasture productivity. Fertility and pasture rest periods can change species dominance dramatically by changing selection pressures and allowing productive species to recover.

Effects of Pasture Management on the Soil

Seasonal rainfall and how a pasture soil captures and stores moisture affects forage growth greatly. The soil, water and nutrient holding capacities of the pasture significantly affect forage production. Soil loss from erosion, loss of soil organic material and soil nutrient depletion reduce a pasture's forage production capability. Good pasture management strives to reduce or prevent these losses and at least maintain existing soil quality and nutrient levels. A well managed pasture can both improve soil quality and quantity, and build up nutrient levels in the soil.

GROUND COVER

Ground cover is important on pastures to protect soil and maintain soil moisture and nutrients. Appropriate levels of live plant material, litter and soil organic matter improve the water holding capacity of the soil, increase water infiltration, reduce evaporation and return nutrients to the soil.

Appropriate live plant and litter levels on pastures vary with environment and forage species present. For example, bunchgrasses tend to have less litter than creeping rooted grasses. Litter from productive tame forages in higher rainfall areas breaks down rapidly in the soil, so it may be less obvious than in drier areas. Bare soil is more susceptible to raindrop impact and aggregate breakdown, leading to increased soil sealing and erosion. Plant material, living and dead, reduces the force of impact from raindrops, leading to better water infiltration. Improve litter levels by enhancing desirable plant production and vigour, allowing some litter to accumulate during the grazing season and winter feeding on pastures.

While a lack of litter reduces forage production on a pasture, too much litter may also reduce productivity. Excessive accumulations of litter may reduce forage production by choking out plants and reducing soil temperatures. Excess litter can also absorb moisture from light rains, preventing it from soaking into the soil. Accumulated litter layers of 8,000 kg/ha or more may reduce forage production on some native prairie sites. This situation is rarely a problem in Alberta pastures where litter helps in conserving critical soil moisture.

Litter levels on most Alberta pastures are more typically in the 100 to 1,000 kg/ha range. At these levels, litter provides valuable soil protection rather than reducing forage production.

SOIL EROSION AND COMPACTION

Soil erosion by wind or water, loss of soil organic matter and soil compaction all reduce forage production potential on a pasture. Reduce soil damage by trampling, erosion and compaction by reducing the amount of bare soil present on the pasture. This objective is best achieved by increasing plant density, increasing plant vigour and increasing ground covered by litter. A vigorous growing plant canopy protects the soil surface.

SOIL EROSION BY WIND

A mixture of species that include fibrous roots to hold the soil and taproots that grow into the lower soil layers helps promote drainage and aeration and reduces soil compaction. Include suitable creeping rooted forage species in pasture mixtures to create a sod, especially on heavier soils and in moist areas to reduce soil damage. Grassed waterways and managed buffer zones along streams and rivers reduce soil and nutrient loss in runoff.

SOIL FERTILITY

Soil fertility is critical to forage production on tame pastures. Fertility also determines the forage species that will dominate a pasture. Correcting nitrogen and phosphorus deficiencies can shift a pasture from one dominated by Kentucky bluegrass to one dominated by smooth bromegrass, alfalfa and clovers over three or four years. This species shift results in a substantial increase in forage production.

Pastures are often located on low fertility soils, so forage stands typically respond markedly to added fertility. Production response to fertilizer depends on existing soil nutrients, climatic conditions, soil type and forage species. Grass species respond well to nitrogen fertilizer on most Alberta soils, but forage increases are much greater in moist areas than dry areas. In a study by Malhi, Gill, McCartney and Malmgren, on average, adding 50 kg of nitrogen per hectare has been shown to increase forage dry matter production on grass stands by 0.5 t/ha on Brown soils, 1 t/ha on Dark Brown soils, 1.3 t/ha on Gray soils and 2.3 t/ha on Black soils. In Alberta, nitrogen and phosphorus are often lacking on pastures, while potassium and sulphur may be deficient on some soils. Other nutrients are generally adequate on pastures (see the Forage Fertility section for more information on soil nutrients and forage production).

Commercial fertilizer is not the only way to improve soil nutrient levels on pastures. Managers can also change soil nutrient levels through pasture management, applying manure, using legumes and winter feeding on pastures. Good grazing management helps maintain or even enhance nutrient cycling on pastures.

Grazing methods that increase stock density and give more uniform pasture utilization improve the distribution of manure onto pastures. Grazing livestock recycle 60 to 95 per cent of the nutrients they eat through their manure and urine. Without management, manure tends to accumulate near water sources and trees, places where livestock loiter. Ensure nutrients are spread back onto pastures by fencing stock out of the bush and providing water in each paddock. Cross fencing pastures into smaller paddocks will also help ensure more uniform manure distribution across pastures.

GOOD MANURE DISTRIBUTION ON PASTURE

Match Forage Quality and Quantity to Animal Needs

PLANT PHYSIOLOGY AND GRAZING

Understanding how grasses and legumes grow and develop is critical for good pasture management decisions. Grazing decisions are based mainly on plant growth stage and on how the timing of grazing affects plant vigour and survival. All plants need a recovery or rest period after grazing to stay vigorous. The length of the recovery period depends on when and how the plants are grazed, what growth stage they are in and the plant type. Some understanding of plant physiology makes this period easier to determine.

COMPARING COOL-SEASON (C3) AND WARM-SEASON (C4) PLANTS

Alberta's forage plants are predominantly cool-season (C3) plants. These plants have their highest growth rate during the cooler and wetter parts of the growing season: spring and fall. Legumes grow more uniformly throughout the growing season, but have their most rapid growth in the spring. Cool-season plants are adapted to temperate environments and prefer to grow in an average temperature of 20 to 25° C. Cool-season species grow slowly below 5 to 7° C and above 30 to 35° C. Some species go dormant at temperatures around 30° C. Alfalfa is a C3 legume that grows well at temperatures above 30° C, but most C3 legumes such as red clover prefer cooler temperatures.

Warm-season plants use somewhat different metabolic processes to grow, making them better adapted to hot, dry environments. The optimum temperature for warm-season species is about 30 to 35° C, and they grow slowly at temperatures below 15° C. Blue grama grass is a native warm-season plant found in southern Alberta. Corn, sorghum and switchgrass are also warm-season grasses. These species grow well under hot, dry growing conditions where C3 species go dormant. While warm-season grasses out-produce cool-season grasses in hot, dry environments, cool temperatures limit their production in Alberta.

LOCATION OF GROWING POINTS

Grass plants have adapted to grazing. They have many growing points at the base of the plant. Grasses can produce new tillers from ground level. Growing points in many tillers also stay at or near ground level, below bite height. When animals bite leaf ends off the vegetative shoot, the growing point is left on the plant, and the leaves keep growing. In spring, most grasses have low growing points and tolerate grazing well. Species like timothy and smooth bromegrass quickly produce a lot of flowering stems with elevated growing points, resulting in slower recovery from grazing.

Grasses can be divided into short-shoot and long-shoot plants (Table 34). Short-shoot grasses have many growing points below bite height and recover quickly from grazing. Short-shoot plants have few elongated stem internodes, and most growth stays relatively low to the ground. Leaves are pushed up into the canopy, but few stems and seed heads are produced. These plants generally work well for pastures, since they recover more quickly from grazing.

When grasses produce a flowering stalk, the growing point is elevated to become the seed head. If an animal bites off this growing point, the shoot stops growing, and new growth has to come from buds or growing points at ground level, resulting in slower regrowth. Long-shoot grasses develop a greater percentage of seed heads and stems. Long-shoot grasses are preferred for hay, since their growth is more easily harvested mechanically. They are less adapted for use as pastures since they take longer to recover after grazing.

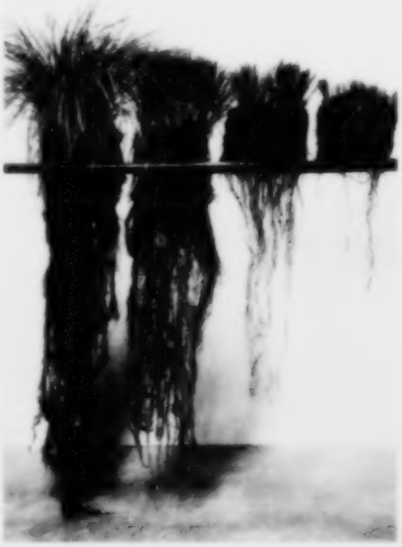
In legumes, dominant growing points are located at the ends of stems and branches. When these are grazed off, regrowth comes from new buds at ground level. This characteristic makes legumes slower to recover from grazing than short-shoot grass species. Legumes like white clover and kura clover are a bit different. While their growing points are still located at the ends of stems and branches, many stems grow prostrate or low to the ground, so some growing points remain inaccessible to livestock. This trait lets them recover from grazing faster than other legumes.

TABLE 34
Long-shoot and short-shoot grasses commonly used for Alberta pastures

Long-shoot (Hay Type) Grasses	Short-shoot (Pasture Type) Grasses
Timothy	Meadow Bromegrass
Smooth Bromegrass	Perennial and Italian Ryegrass
Crested Wheatgrass	Orchardgrass
Intermediate and Pubescent Wheatgrass	Russian and Altai Wildrye
Western and Northern Wheatgrass	Kentucky Bluegrass
Tall Wheatgrass	Creeping Red Fescue
Reed Canarygrass	Tall Fescue

GRAZING EFFECTS ON ROOT SYSTEMS

Grazing affects plant root growth as well as above-ground growth. In bunch grasses, if less than 40 per cent of the above-ground material is removed, root growth continues unaffected. When 50 per cent of the above-ground material is removed, root growth slows until the plant recovers from grazing by replacing leaves. If 80 per cent of above-ground material is removed, root growth stops. Root recovery takes three to four weeks, since replacing leaves takes priority. When plants are kept grazed down without a recovery period, roots become increasingly shallow. This situation makes plants more susceptible to drought and less competitive with weeds.



ROUGH FESCUE ROOTS WHEN FOLIAGE WAS CLIPPED EVERY FOUR WEEKS FOR FIVE MONTHS - LEFT TO RIGHT: NOT CLIPPED, CLIPPED TO 12.5, 7.5 AND 3.8 CM
(from *Management of Prairie Rangeland*, Agriculture Canada publication 1589/E. 1990)

PLANT ENERGY RESERVES

Plants need energy to grow. During the growing season, most of the needed energy comes from photosynthesis that occurs in the leaves. When a plant is grazed, leaf area is removed. When only a portion of the leaf is removed, the plant continues to photosynthesize and replaces the lost leaf area. However, if a lot of the plant is removed, the plant has to draw on stored carbohydrate reserves to replace the leaf area before it can resume fast rates of photosynthesis.

During the growing season, actively growing plants store extra carbohydrates in the roots, rhizomes and crowns for use later in the year. This energy storage has three key functions:

- to provide energy first thing in the spring to produce the first leaves, so photosynthesis can begin
- to keep the plant alive during winter and during drought when it is unable to produce energy by photosynthesis
- to provide energy for the plant to regrow after grazing

Repeatedly grazing forage plants before they have had a chance to replace carbohydrates used for leaf growth gradually reduces the plant's energy reserves. This condition slows the plant's ability to recover from grazing, makes it less competitive with weeds and other plants and eventually reduces its ability to survive the winter. Spring grazing when carbohydrate reserves are normally low is especially hard on forage plants and will weaken or kill plants unless they are given ample time to recover.

Grazing can be beneficial or detrimental to forage plants depending on how it is done. If grazing animals remove only a small amount of green leaf area, photosynthesis continues, and the plant can maintain leaf and root growth. However, if grazing animals remove most of the available leaf area, the plant has to use root reserves to regrow. If plants are heavily grazed repeatedly before they have an opportunity to recover (overgrazing), the root system runs out of energy reserves and starts to die. Overgrazed pastures produce far below their potential.

All plants need a rest period after grazing to recover their vigour and replace grazed leaf area. The amount of rest a plant needs depends on the amount of leaf area left behind after grazing and the timing of grazing in the growing season.

In ideal spring growing periods, grasses that are ready to be grazed may recover from grazing in two to three weeks, while during the summer, when growing conditions are less favourable, the same plants may need six weeks or more to recover.

The rest period is shorter when more leaf area is left behind after grazing. The remaining leaf area contributes to photosynthesis and helps plants recover. Soil moisture and daily temperature also affect the length of the rest period. Plant rest periods are only effective during the growing season when the plant has the resources to regrow. If limited moisture is available or it is too cold, the plant will not regrow as quickly as it would under ideal growing conditions. In drier parts of Alberta and during droughts, rest periods need to be longer. Plants may need up to a full growing season or longer to recover from grazing.

Grazing in spring, when forage plants are just starting to grow, can be hard on plants. Forage plants are generally less stressed by grazing as they mature. Pasture management is a compromise between animal needs and plant needs. A rule of thumb is to wait until grasses reach at least the three to four-leaf stage (approximately 15 cm (6 in.) tall) before grazing them, but making sure they are grazed before the plants begin to head. Long-shoot plants are generally more sensitive to early grazing than short-shoot plants.

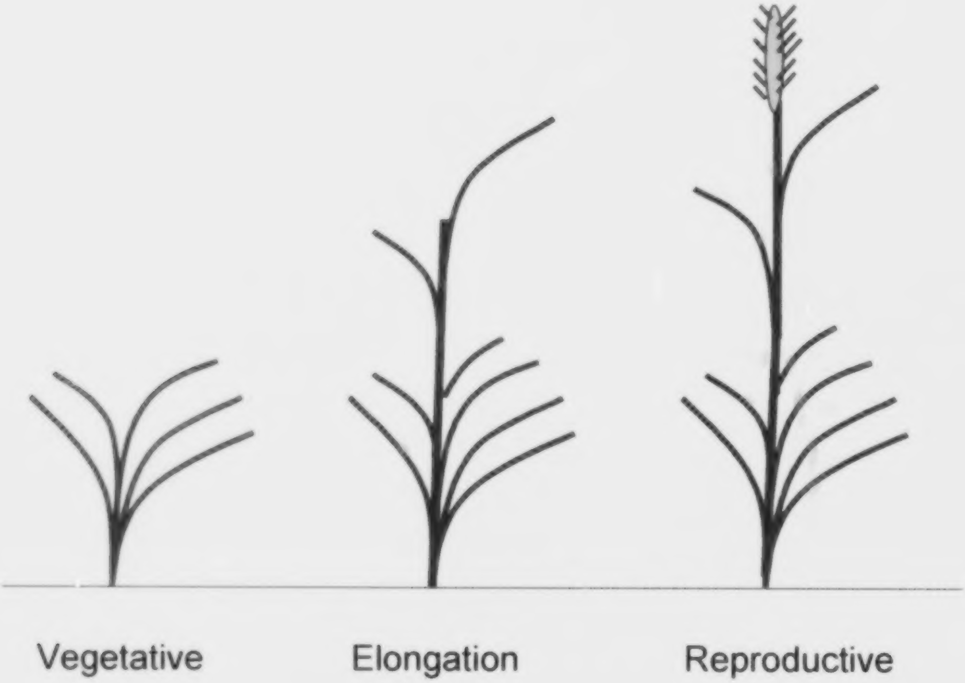
PLANT DEVELOPMENTAL STAGES

Grass plants go through several developmental stages. Three primary growth stages important for good pasture management:

- **Vegetative**
  This stage is when leaves are developing, and stems are not visible.
- **Elongation**
  This is the period when stem internodes elongate. The stage ends when the seed head is just visible through the leaf sheath.
- **Reproductive**
  This stage is when the seed head develops and pollination occurs.

As grasses move from the vegetative stage through the reproductive stage, they continue to grow (yield increases) until the seeds start to ripen. Plant growth rates are slow when the plants are small and have few leaves for photosynthesis. As leaf area increases, so does growth rate. Plants reach maximum growth rates at the late vegetative stage. As stems progress to the reproductive phase, growth rates slow and dry weight is transferred from the leaves to the seeds.

Pastures do not grow at the same rate through the growing season. Forage growth of cool-season plants is rapid in the spring and early summer and slows in late summer and fall. Livestock, especially calves and feeders, need more forage as the summer progresses, but the forage plants are growing more slowly. Pasture management in Alberta depends on managing and accumulating forage early in the growing season, so it can be allocated to livestock later in the growing season.



PASTURE QUALITY

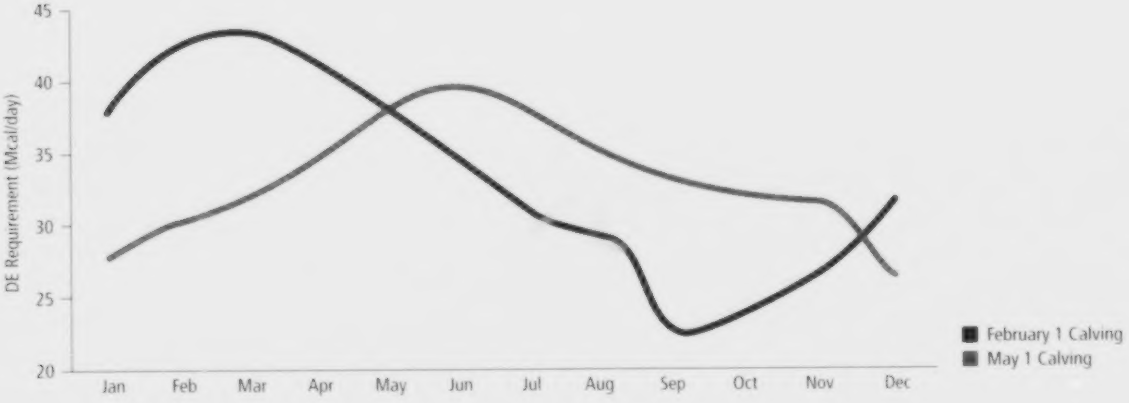
Pastures generally provide adequate nutrients for most classes and species of grazing animals. Nutrient requirements of livestock vary throughout the year (Figure 74). The nutrient requirements of beef cows are highest from just before calving until the end of the breeding season. Requirements drop significantly for dry cows after the calves are weaned. Forage quality and quantity also changes through the growing season. Matching the animal's nutrient needs to forage quality through the growing season will improve the profitability of pasture systems. This objective can be achieved by moving calving dates to more closely match pasture readiness and forage quality.

Forage quality on pastures depends mainly on plant growth stage. Forage species present have only a small effect on forage quality. Plant leaves are good sources of energy and protein for livestock. Grass stems and leaf sheaths are more fibrous and are lower in nutritive value. Old stems are very low in energy and protein. As plants mature, their nutritive value declines. Once grasses become reproductive and form seed heads, their nutritive value drops further. Mature grasses may meet the nutritive needs of dry beef cows in early to mid-pregnancy, but they are too low in quality for most other livestock.

Grasses typically contain more fiber and have slightly lower nutrient values than legumes. Legumes typically contain more energy and protein than grasses, and even as they mature and lose quality, legumes will still meet the nutritional needs of most livestock.

Generally, livestock production is not limited by forage quality on pasture. Dairy cattle and feeder cattle are exceptions and may require supplementary energy and occasionally protein to maintain maximum production on pasture. More often on Alberta pastures, animal production is limited by pasture yield, which controls the amount of forage an animal can consume in a day.

FIGURE 74
Annual digestible energy requirement (Mcal/day) of 635 kg (1,400 lb) crossbred beef cow bred to calve on either February 1 or May 1



Note: The energy requirement patterns were calculated from digestible energy requirements of a 635 kg (1,400 lb) crossbred beef cow with a peak milk yield of 9 kg and an expected calf birth weight of 41 kg using CowBytes software.

Sources:
Alberta Agriculture and Rural Development. 1999. CowBytes 4. Home Study Program, Alberta Agriculture and Rural Development, Edmonton, Alberta

LIVESTOCK SPECIES DIFFERENCES

Animal species differ in how they graze and have different nutritional requirements. Cattle and bison are mainly grazers, adapted to eating large quantities of fairly low quality grass. Sheep and elk consume greater proportions of forbs (herbaceous plants other than grasses), trees and shrubs to meet their higher nutritional requirements. Goats and deer are browsers and consume mainly forbs, shrubs and trees, which provide more concentrated nutrients than they can get from a grass diet.

Different animal species have different effects on pastures and pasture plants. Cattle and bison have no upper teeth, so they tear off the grass. They cannot graze right to the ground, so they need enough forage to collect with their tongue. Sheep, elk and horses are able to clip grasses much closer to the ground. They can graze lower on the plant and damage plants more easily.

Animal Type

Within each animal species, nutrient requirements vary with animal type. Young calves need higher quality forage than mature cows. Dry beef cows have a fairly low nutrient requirement, which can be easily met on most pastures. Lactating beef cows need higher quality forage and more quantity, while high producing dairy cows may not be able to meet their nutritional needs even on the best pasture without supplementation. Feeder cattle need higher qualities and quantities of forage to maximize growth rates on pasture.

Pasture profitability can be improved by matching animal requirements to forage quality on the pasture. Since the nutritional requirements of beef cows change dramatically with calving, the calving period can be moved to match more closely with forage quality and quantity on pasture.

Animal Size

Animal size affects forage and nutrient requirements of animals on pasture. A 680 kg (1,500 lb) cow raising a 270 kg (600 lb) calf needs significantly more forage than a 500 kg (1,100 lb) cow with a 180 kg (400 lb) calf. Differences in livestock species, breed, size, productive ability and status all affect how much forage they need.

Beef cattle generally consume 2 to 3 per cent of their body weight as dry matter each day. Growing calves and thin cows will consume 2.5 to 3 per cent of body weight, while cows under normal feeding conditions usually consume 2 to 2.5 per cent of body weight. Sheep, goats and bison are similar to cattle and consume 2 to 3 per cent of their body weight daily. Horses need more forage and will consume 4 per cent of their body weight as dry matter each day.

The animal unit (AU) was developed to allow comparison of different kinds of livestock on pasture (Table 35). An animal unit is based on forage consumption by a 454 kg (1,000 lb) cow with or without a calf. Traditionally, 13 kg/day (28 lb/day) of forage dry matter consumption (380 kg/month or 840 lb/month) was used.

More forage needs to be accounted for than just the forage used by livestock when determining pasture stocking rates. Trampling, fouling and insects reduce forage availability. In addition, adequate plant residue must be left behind after grazing to sustain perennial plants. When calculating stocking rates based on pasture forage production, allowances for trampling, fouling, insect damage and residue must be taken into consideration.

Usually, the animal unit is used in conjunction with time. For example, sufficient forage per animal unit for a month is an animal unit month (AUM). The animal unit is adjusted for other animals by adjusting for animal type, class or size and is given animal unit equivalents (AUE). This adjusts for animal weight and intake. Pasture stocking rates can be compared when animals are adjusted to a common unit. The animal unit also allows average recommended stocking rates to be determined for different areas and pastures.

PASTURE STOCKING RATES CAN BE COMPARED WHEN SPECIES ARE ADJUSTED TO ANIMAL UNIT EQUIVALENCIES

TABLE 35
Animal unit equivalencies (AUE) for species on a body weight basis

Animal Species	Weight in kg (lb)	AUE	Forage DM Intake kg/day (lb/day)
Cattle			
Weaned Calf	225 (500)	0.5	6 (14)
Yearling Heifer or Steer	300 (700)	0.67	9 (19)
Mature Cow with or without Calf	450 (1,000)	1.0	13 (28)
Mature Cow with or without Calf[1]	680 (1,500)	1.5	19 (42)
Bull	680 (1,500)	1.5	19 (42)
Bull	900 (2,000)	2.0	25 (56)
Horses			
Yearling	225 (500)	0.75	10 (21)
Two-year-old	300 (700)	1.0	13 (28)
Three-year-old and Older	450 (1,000)	1.4	18 (39)
Three-year-old and Older	630 (1,400)	2.0	25 (56)
Sheep and Goats			
Weaned Lamb or Kid	45 (100)	0.1	1.3 (2.8)
Ewe or Doe with/without Lamb or Kid	90 (200)	0.2	2.5 (5.6)
Ram or Buck	140 (300)	0.3	3.8 (8.4)
Deer			
	70 (160)	0.25	2.5 (5.5)
Bison			
Yearling	270 (600)	0.6	8 (17)
Cow with or without Calf	450 (1,000)	1.0	13 (28)
Bull	680 (1,500)	1.5	19 (42)
Elk			
Yearling	160 (350)	0.35	4.5 (10)
Cow with or without Calf	270 (600)	0.6	8 (17)
Bull	430 (950)	1.0	13 (28)

[1] Add 0.1 to AUE for every 45 kg. (100 lb) that the AU is over the standard value of 450 kg (1,000 lb) for a mature cow.

Note: Unweaned calves that are born early and have large frames will eat a considerable amount of grass by the end of the grazing season. Over a 165-day grazing period, it is estimated that a calf will consume up to 450 kg (1,000 lbs) of grass and by weaning will be eating as much as 3.5 to 5.5 kg (8 -12 lb) per day of pasture forage, depending on calf size and mother's milk production.

Balance Animal Needs with Forage Produced

Animal forage requirements must be balanced with forage produced on the pasture for economical, sustainable pasture production. Grazing all the available forage allows managers to increase animal numbers in the short term, but damages the forage stand. Grazing with too few animals does not optimize forage use and economic return from the pasture. Since animals are selective grazers, the best individual animal performance is obtained with low stocking rates, so animals can select high quality forage.

AS STOCKING RATES ARE INCREASED, ANIMALS HAVE FEWER OPPORTUNITIES TO SELECTIVELY GRAZE

As stocking rates are increased and animals have less opportunity to select forage, diet quality drops since they are forced to eat more stems and older leaves. As stocking rates are increased, live weight gains per animal are reduced, but live weight gains per hectare will increase to a point before eventually decreasing.

STOCKING RATE AND CARRYING CAPACITY

Pasture productivity depends on soil and climatic conditions as well as pasture condition and management. This situation means accurate pasture carrying capacity and stocking rate need to be determined for each individual pasture. Stocking rate is the number of animal units grazing a specific unit of land for a specific length of time (for example 30 cow-calf pairs in a 36 hectare pasture for 45 days). The stocking rate will vary over the season, depending on production. Carrying capacity is the maximum total stocking rate that can be achieved over a specified length of time (for example AU/ha for the grazing season). The sum of all grazing days and stocking rates will determine the maximum carrying capacity of the pasture, which maintains a target level of production without affecting the ecosystem.

Average carrying capacity is a long-term average, since carrying capacity will vary from year to year. In a rotational grazing system, the stocking rates may be different each time the pasture or paddock is grazed. The cumulative or seasonal stocking rate for all the grazing rotations will be the carrying capacity of the pasture. The carrying capacity determines the animal units that the pasture will sustain over the years using the present pasture management and grazing system.

To be sustainable, enough plant residues must remain at the end of the grazing season to keep the pasture in good condition and to protect the soil. Annual records of carrying capacity on a pasture or paddock are the best guides to stocking rates.

The best way to determine stocking rates is to determine the forage production for representative areas in the pasture. Clipping and weighing samples to determine pasture yield is the most accurate, but you can estimate stocking rates from how many animals the pasture carried in previous growing seasons and for how long. If pasture condition is good, the current stocking rate is a good place to start. If the pasture appears to have been overgrazed, reduce the stocking rate.

Finally, stocking rate averages for the area can be used as a starting point. Keep in mind that estimates and averages can easily over or underestimate pasture production, leading to overgrazing or a forage surplus.

Examples of Determining Stocking Rate

Estimated Stocking Rate in AUM per Hectare of Pasture

Pasture forage available = 1,460 kg/ha (1,300 lb/ac)

Cows weighing 635 kg (1,400 lbs) need 18 kg (39 lb) of forage per day or 540 kg (1,170 lb) per month.

$$\text{Stocking Rate} = \frac{\text{Pasture Production}}{\text{Forage Needed/Animal/Month}}$$

$$\text{Stocking Rate} = \frac{1{,}460\ \text{kg/ha}}{540\ \text{kg/AU}} = 2.7\ \text{AUM/ha}\ (1.1\ \text{AUM/ac})$$

Estimated Stocking Rate in AUD per Hectare of Pasture

Pasture forage available = 1,460 kg/ha (1,300 lb/ac)

Cows weighing 635 kg (1,400 lb) need 18 kg (39 lb) forage per day

$$\text{Stocking Rate} = \frac{\text{Pasture Production}}{\text{Forage Needed/Animal/Day}}$$

$$\text{Stocking Rate} = \frac{1{,}460\ \text{kg/ha}}{18\ \text{kg/AU}} = 81\ \text{AUD/ha}\ (33\ \text{AUD/ac})$$

Average seasonal carrying capacities for seeded tame pastures in Alberta are given in Table 36. These averages assume average inputs and a continuous grazing method. Higher carrying capacities may be achieved when using a fertility program and more intensive grazing methods. The condition class estimates pasture yield over the season and can be used to determine stocking rates and carrying capacities. Tame pasture condition class depends on past management. Trampling and carry-over need to be allowed for when estimating carrying capacities. Pasture condition classes are given in Table 37.

TABLE 36
Carrying capacities (AUMs/hectare) and average forage production for seeded tame pastures in four condition classes in Alberta

Annual Precipitation Zones –	Pasture Condition Class							
mm (inches)	Excellent		Good		Fair		Poor	
	AUM/ha (AUM/ac)	Forage Production kg/ha Hay (lb/ac)	AUM/ha (AUM/ac)	Forage Production kg/ha Hay (lb/ac)	AUM/ha (AUM/ac)	Forage Production kg/ha Hay (lb/ac)	AUM/ha (AUM/ac)	Forage Production kg/ha Hay (lb/ac)
250-350 (10-14)	1.85 (0.75)	780 (700)	1.25 (0.50)	515 (460)	1.00 (0.40)	410 (370)	0.60 (0.25)	260 (230)
350-450 (14-18)	3.00 (1.25)	1,300 (1,150)	2.00 (0.80)	830 (740)	1.50 (0.60)	620 (550)	1.00 (0.40)	410 (370)
450-550 (18-22)	5.00 (2.00)	2,070 (1,850)	3.50 (1.40)	1,460 (1,300)	2.70 (1.10)	1,120 (1,000)	1.75 (0.70)	730 (650)
550-650 (22-26)	8.20 (3.30)	3,360 (3,000)	5.45 (2.20)	2,240 (2,000)	4.00 (1.60)	1,680 (1,500)	2.70 (1.10)	1,120 (1,000)
Irrigation	18.50 (7.50)	7,730 (6,900)	12.35 (5.00)	5,150 (4,600)	9.25 (3.75)	3,920 (3,500)	6.20 (2.50)	2,580 (2,300)

To convert AUM/ha to AUM/ac, divide by 2.47.

Adapted from Wroe et al. Guide to Range Condition and Stocking Rates for Alberta Grasslands, 1988

TABLE 37
Tame pasture condition class definitions

Condition	Definition
Excellent	
	75 to 100% of the potential yield for the area
	95% of production comes from desirable, adapted grasses and legumes
	Less than 5% of total production comes from weeds or undesirable plants
	Fertility program average to above average
Good	
	60 to 75% of the potential yield for the area
	90% of production comes from adapted species
	Less than 10% of production comes from weeds or undesirable plants
	Fertility program average
Fair	
	50 to 60% of the potential yield for the area
	60% of production comes from adapted species
	20% or more of total production comes from weeds or undesirable plants
	Fertility program below average or non-existent
Poor	
	33 to 50% of the potential yield for the area
	Less than 50% of production comes from adapted species
	50% or more of total production comes from weeds or undesirable plants
	No fertility program

Adapted from Wroe et al. Guide to Range Condition and Stocking Rates for Alberta Grasslands, 1988

Note: Legumes may or may not be used in productive tame pastures. Utilizing 40 to 50 per cent legumes in the pasture may reduce the need for the addition of nitrogen fertilizers under good forage and grazing management. See the Forage Fertility section for the factors affecting good nitrogen fixation in legumes and nutrient cycling in pastures.

Examples:
Determining Pasture Size Needed Based on Cow Size and Average Carrying Capacity

Estimated Pasture Needed in the Black Soil Climatic Zone

Assumptions:
- 400 mm annual precipitation
- 80 cows weighing 680 kg (1,500 lb) with calves (120 AU)
- Good pasture condition class, carrying capacity of 2.00 AUM/hectare (0.8 AUM/ac)
- Grazing season May 1 to October 15 (5.5 months)

$$\text{Required Pasture} = \frac{\text{AU x Months Grazing}}{\text{AUM/hectare}}$$

$$\text{Required Pasture} = \frac{\text{120 AU x 5.5 months}}{\text{2 AUM/hectare}}$$
$$= \text{330 hectares (825 acres) for the grazing season}$$

Estimated Pasture Needed in the Brown Soil Climatic Zone

Assumptions:
- 300 mm annual precipitation
- 80 cows weighing 450 kg (1,000 lb) with calves (80 AU)
- Excellent pasture condition class, carrying capacity 1.85 AUM/hectare (0.75 AUM/ac)
- Grazing season May 1 to October 15 (5.5 months)

$$\text{Required Pasture} = \frac{\text{AU x Months Grazing}}{\text{AUM/hectare}}$$

$$\text{Required Pasture} = \frac{\text{80 AU x 5.5 months}}{\text{1.85 AUM/hectare}}$$
$$= \text{238 hectares (587 acres) for the grazing season}$$

**Examples:
Determining Pasture Carrying Capacity**

Estimated Pasture Carrying Capacity in the Black Soil Climatic Zone

Assumptions:
- 400 mm annual precipitation
- 80 ha (200 acre) grass-legume pasture, excellent condition, carrying capacity 3.0 AUM/hectare (1.25 AUM/ac)
- Desired grazing season 4 months

$$\text{Pasture Carrying Capacity} = \frac{\text{Hectares x AUM/hectare}}{\text{Months grazing}}$$

$$\text{Pasture Carrying Capacity} = \frac{\text{80 ha x 3.0 AUM/hectare}}{\text{4 months}} = \text{60 AU}$$

60 AU equivalents are 60 small cow/calf pairs (60 AU / 1.0 AU equivalents), 40 large cow/calf pairs (60 AU / 1.5 AU equivalents) or 90 yearlings (60 AU / 0.67 AU equivalents).

Estimated Pasture Carrying Capacity in the Brown Soil Climatic Zone

Assumptions:
- 300 mm annual precipitation
- 65 hectare (160 acre) grass pasture, good condition, carrying capacity 1.25 AUM/hectare (0.50 AUM/ac)
- Desired grazing season 5.5 months

$$\text{Pasture Capacity} = \frac{\text{Hectares x AUM/hectare}}{\text{Months grazing}}$$

$$\text{Pasture Capacity} = \frac{\text{65 ha x 1.25 AUM/ha}}{\text{5.5 months}} = \text{14.8 AU}$$

14.8 AU equivalents are 15 small cow/calf pairs, 10 large cow/calf pairs or 22 yearlings.

Estimated Paddock Carrying Capacity in AUDs

Assumptions:
- 475 mm annual precipitation
- 8 ha (20 acre) grass paddock, good condition, carrying capacity 3.5 AUM/ha or 105 AUD/ha
- Desired grazing period 7 days

$$\text{Pasture Capacity} = \frac{\text{Hectares x AUD/hectare}}{\text{Days grazing}}$$

$$\text{Pasture Capacity} = \frac{\text{8 ha x 105 AUD/ha}}{\text{7 days}} = \text{120 Animal Units}$$

The paddock would support 120 small cow/calf pairs or 179 yearlings for 7 days.

Match Grazing Method to Plant and Animal Needs

Managing pastures involves compromises. Livestock need to eat the same green leaves the plant uses to grow and recover from grazing. The more active leaf area plants have, the quicker their growth rate. Harvesting forage does slow plant growth rate, but the benefit is that the forage can be harvested and put to use. Grazing methods are used to manage this balance between forage growth and livestock consumption.

Several key principles are the same for all grazing methods. Grazing methods vary in how they apply the principles.

- Plants need a rest or recovery period after grazing to remain healthy and productive.
- Grazing pressure - the forage available relative to animal intake - can be manipulated to achieve specific plant and animal goals.
- When animals are concentrated (high stock density), they graze more uniformly, with less selection of desirable forage. Increasing stock density improves forage utilization (percentage of forage removed).
- Pasture plants grow and mature at different times and rates, so methods must be flexible in timing of use.
- Grazing methods must accommodate changes in the environment, markets and production conditions. The grazing method may include some way of conserving forage for deficit times, since forage growth in some parts of Alberta is concentrated in the spring and early summer and drought is common.
- Grazing methods are effective only when used with the correct carrying capacity.
- Match forage quality and quantity to animal needs.

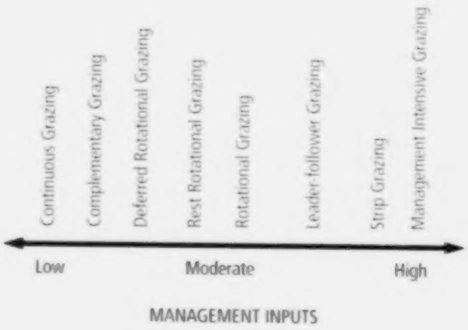
Grazing Methods

A grazing method is a management tool used to obtain specific objectives. More than one grazing method may be used during the growing season. Grazing methods use key plant and animal principles to achieve specific management goals. Grazing methods help managers manipulate animal use and control uniformity of intake. They typically vary rest or recovery periods, stock density and/or timing of use.

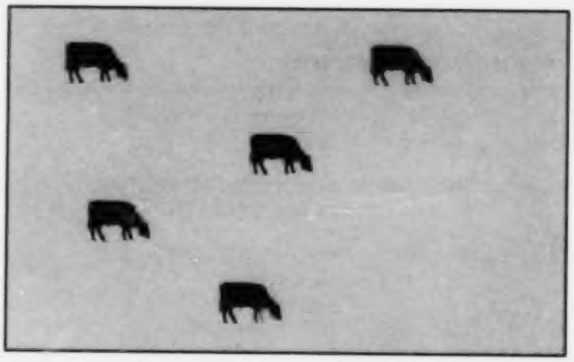
Grazing methods are often categorized as intensive or extensive, depending on the amount of labor and other inputs that go into making the method work. Intensive or extensive methods are not intrinsically good or bad. Different methods fit better with some management goals and environments than others.

Various grazing methods can be placed along a continuum of management intensity (Figure 75). Choosing an appropriate grazing method depends on assessing the input costs relative to increases in productivity and economic return. The most return comes from correcting the most limiting factor first. In areas where the most limited resource is precipitation, extensive grazing methods with lower input costs may be more economical. Where precipitation is higher, return on investment to intensive grazing methods tends to be higher. As pasture management is intensified, increased productivity can often be realized. However, costs and labor will also increase. Managers need to compare the returns from management to the additional costs incurred to achieve the return.

FIGURE 75
Continuum of grazing methods from low management and inputs to high management



CONTINUOUS GRAZING



Continuous grazing is a one-pasture grazing method, where livestock have unrestricted access to a given unit of land for long grazing periods. Continuous grazing works best on large, low producing pastures. The method relies on animal movement through the pasture to provide rest and recovery time for plants. Animals are free to select where, what and when they graze.

To be effective, stocking rates for continuously grazed pastures must be low enough to ensure forage carry-over. Continuous grazing is useful where pasture is plentiful and the manager does not want to increase livestock numbers. This system is most successful when used with beef cows of low to moderate milking ability, growing heifers, sheep or dry cows.

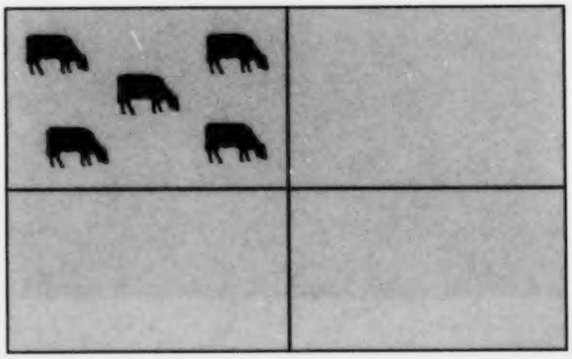
Advantages
- requires less day-to-day management
- lower fencing and water development (capital) costs
- with modest stocking rates, animals can select quality forage for good individual gains

Disadvantages
- lower stocking rates and less forage produced per hectare
- uneven pasture use creates overgrazed and underused areas of pasture
- lower overall forage quality
- overstocking may be harder to recognize than in rotational grazing methods
- greater forage losses due to trampling
- uneven distribution of animal manure
- weeds and other undesirable plants may be a problem

OVERGRAZED PASTURE

Additional grazing management can be added to a continuous grazing method to improve pasture productivity and reduce some negative effects. Water development, herding and/or placing salt or supplement in underused areas will improve animal distribution. These activities increase the cost and management needed, but will provide some plant rest and give some control over utilization, particularly on large pastures.

SIMPLE ROTATIONAL GRAZING



Simple rotational grazing uses two or more pastures. Animals are moved from one pasture or paddock to the next. This approach concentrates the grazing on one pasture and then moves it to a new pasture. Rotations allow the manager to manage rest and regrowth between defoliations. At least two pastures are needed for a simple rotation, although often more are used. Rotational grazing may help the manager increase animal production per hectare.

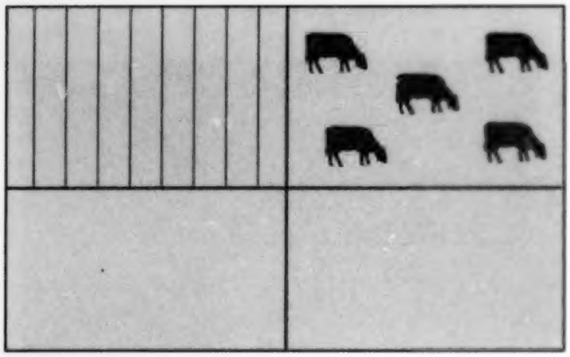
Advantages

- manager has more control over timing and intensity of forage harvest by livestock
- provides more even grazing, resulting in fewer over and undergrazed areas
- may increase forage production and improve pasture condition over continuous grazing
- overall healthier plants and root systems reduce weed problems and improve drought tolerance
- allows pastures to rest and forages to regrow
- may provide a longer grazing season
- improved distribution of manure over pasture
- improves productivity of forage species like alfalfa, which benefit from longer rest periods

Disadvantages

- management needs increased over continuous grazing (more time spent checking and moving stock)
- costs for fencing and water systems can be higher than with continuous grazing
- forage production and pasture utilization is not as high as intensive rotational grazing methods

DEFERRED ROTATIONAL GRAZING



In deferred rotational grazing, each pasture is periodically deferred, or not grazed, until a specific time (often after seed set). Every few years, the deferred pasture is allowed to grow and produce seed during the spring and early summer, when growing conditions are good. Pastures may be deferred in sequence to allow all to recover, or they may be deferred depending on need.

Deferred rotational grazing was designed for managing dry native rangeland. Most rotational grazing methods now encourage alternating which pastures are used early in the grazing season. This is a good way to keep all pastures healthier, since they all have a chance to periodically renew root reserves, plant vigour and possibly set seed. Deferred rotational systems are also used to keep animals out of areas like riparian zones along creeks or native pastures during times when they might do damage.

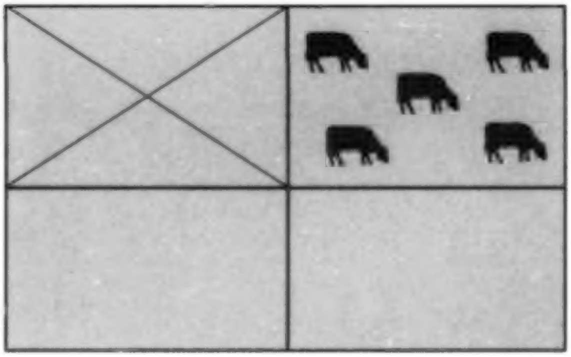
Advantages

- varying timing of grazing helps maintain high plant vigour
- protects vulnerable areas when they are most sensitive

Disadvantages

- mature forage in rested pasture is less palatable, reducing utilization

REST ROTATIONAL GRAZING



Rest rotational grazing was developed for mountain rangelands and usually involves at least four pastures. One pasture is rested or not used for a full year, while the others carry the full grazing load. Rest rotational systems are used to allow slow growing native plants to regain their vigour and set seed. The system also helps allow litter to accumulate more rapidly and is best used for dry rangeland areas where significant pasture recovery is needed.

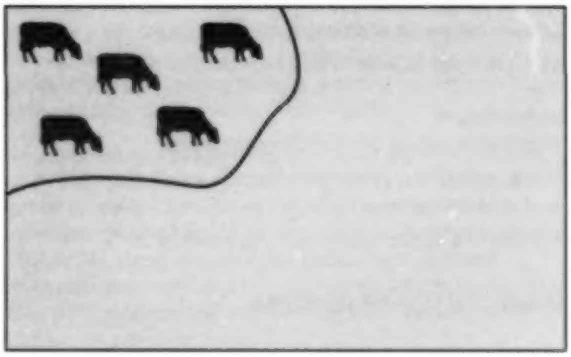
Advantages

- allows overgrazed pastures maximum opportunities to regain plant vigour and re-seed

Disadvantages

- may need to reduce stocking rate to avoid overgrazing
- excessive forage may accumulate in rested pasture in moist ecosystems
- brush and tree growth may increase with rest in areas where these species invade pastures

COMPLEMENTARY GRAZING



Complementary grazing is a simple rotational grazing system designed for pastures with very different forage components. Complementary grazing is often used to protect native rangelands, where livestock graze tame pastures in the spring and early summer before moving onto native pastures. This method also works well when specific stockpiled or calving pastures are used before turnout into the main pasture, with annual forages to fill in the slow growth period in midsummer or to rest perennial pastures in late summer and early fall.

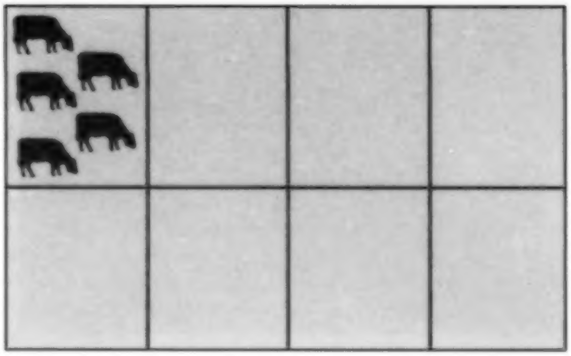
Advantages

- allows pastures with different plant species, growth rates and sensitivity to grazing to be used at the appropriate time for each species, enhancing overall productivity
- provides opportunities for pasture rest and regrowth

Disadvantages

- increased management needed
- costs for fencing and water development may be higher

INTENSIVE ROTATIONAL GRAZING (MANAGEMENT INTENSIVE GRAZING)



Intensive rotational grazing involves a number of pastures, often called paddocks. Livestock are moved frequently from paddock to paddock based on forage growth and utilization. Paddocks may be permanently fenced, or fences may be temporary and flexible. A grazing rotation using more than seven or eight paddocks provides ample plant recovery time and allows managers more control over forage utilization and quality.

Intensive rotational grazing is well suited for young growing stock, high producing beef cattle and intensively managed sheep and dairy cattle. This management method uses increased stocking rates, forage utilization, labor or capital to increase potential production or utilization per unit area or production per animal.

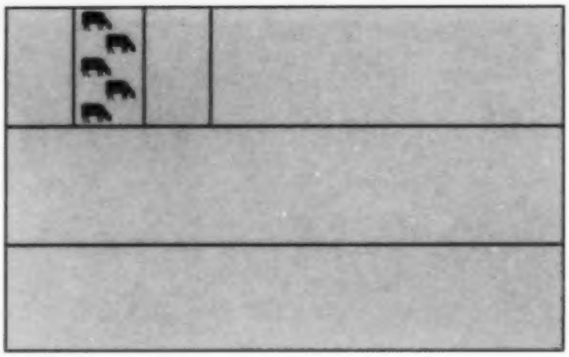
Advantages

- highest forage production and use per hectare
- allows control of timing of grazing relative to plant growth stage, allowing improved livestock performance
- provides even grazing, with fewer areas of over or undergrazed forage
- can be used to ration forage to animals that do not need maximum intake
- may be able to increase stocking rates
- more even distribution of manure throughout paddocks
- weeds and brush are usually controlled by grazing
- provides more grazing options and reduces the need for mechanically harvested forage
- grazing timing and intensity can accommodate different forage species and growing conditions in different paddocks

Disadvantages

- requires more management than continuous or simple rotations
- requires careful monitoring of forage supply
- initial costs may be higher due to fencing and water distribution systems
- field operations such as fertilizing may be more difficult due to size and possibly shape of paddocks

STRIP GRAZING



Strip grazing is a variation of intensive rotational grazing, where livestock are confined to a small area to graze in a relatively short time. Paddock size often varies with forage growth and animal requirements. Livestock are moved frequently, often once or twice daily. Cross fences must be temporary to allow for variations in paddock size.

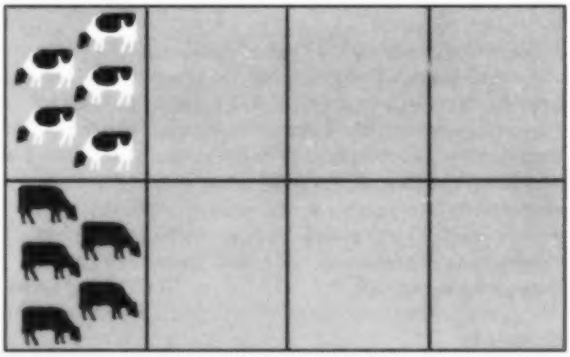
Strip grazing is often used to provide consistently high quality forage to growing beef animals or dairy cows. Strip grazing maximizes forage utilization and can also be used to limit-feed livestock that do not need to graze to capacity for production. A back fence is generally used to prevent the animals from regrazing the area previously grazed.

ELECTRIC FENCE IS AN EFFECTIVE TOOL WHEN STRIP GRAZING

Advantages
- high degree of control over forage utilization and animal intake
- enables high animal productivity every day
- very even distribution of manure over pasture

Disadvantages
- high management and time inputs needed
- requires careful monitoring of forage supply and animal intake
- fencing and water system costs may be higher

LEADER-FOLLOWER GRAZING



Leader-follower grazing is an intensive rotational grazing method where livestock are divided into two or more groups based on their nutritional requirements. The group with the higher nutritional requirement (often feeder cattle) grazes the paddock first and is then moved on to the next paddock. Livestock with the lower nutrient requirements (often beef cows) are then moved onto the paddock to finish harvesting the forage. This method is usually used in a grazing rotation to maximize the use of forage.

Advantages
- provides high quality forage to animals with the highest nutritional requirements
- allows utilization of the lower quality forage by animals with lower nutritional requirements

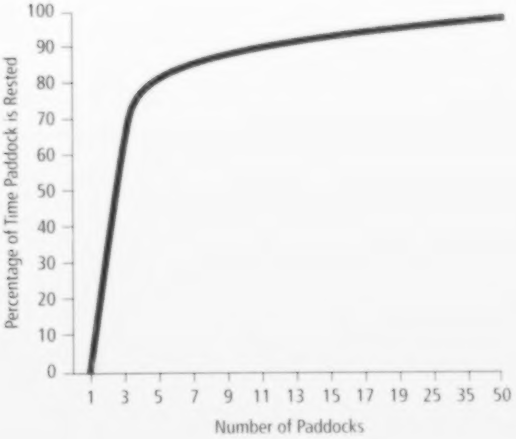
Disadvantages
- increased management needed to provide adequate nutrition to two groups of cattle and still maintain utilization
- requires careful monitoring of forage supply, forage quality and animal intake
- fencing and water system costs may be higher
- requires two different animal herds
- need to move two herds of animals in each rotation

Benefits of Rotational Grazing

In its simplest form, rotational grazing consists of having two or more paddocks and moving animals from one to another. Rotational grazing generally improves plant vigour and productivity by allowing individual plants to rest and recover after grazing, before being bitten again.

Simply dividing a pasture into two has a significant effect, since each paddock is now able to rest 50 per cent of the growing season. Initially, as the number of paddocks increases, the proportion of time plants are rested increases (Figure 76). However, the added advantage to plants gradually decreases, and with 8 or more paddocks, plants are rested 90 per cent of the growing season. Increasing the number of paddocks beyond this number has little further effect on plant growth. However, more paddocks will improve control over animal utilization and animal selectivity.

FIGURE 76
Percentage of time a paddock is rested relative to the number of paddocks



While any grazing method can be adapted to work in almost any environment, the more intensive rotational grazing methods tend to work best in areas that have moderate to good annual precipitation and at least three months of plant growth. These areas have the greatest opportunity for plant regrowth during the grazing season, so managing for regrowth is more effective. Areas with higher productivity also tend to have lower fencing requirements and costs per animal, since pastures are relatively smaller.

As stock density is increased in a grazing system, forage utilization is improved and control over animal intake and diet increases. However, increased pasture management skills are also needed. Moving the cow herd even 1 day late in a 30-day grazing period results in overgrazing the pasture by 3 per cent. Moving the herd 1 day late in a 7-day grazing period results in overgrazing the pasture by 15 per cent. Moving 4 hours late in a 24-hour grazing period means overgrazing the pasture by 25 per cent.

Flexibility in the Grazing System

Grazing methods work best when they are flexible. Rotational grazing systems that use fixed grazing times, like moving every seven days or every thirty days, and fixed rotational orders generally do not work as well as systems that have the flexibility to adapt to the environment and growing conditions.

The length of the grazing period should be timed to forage growth rate. In Alberta, forage grasses and legumes grow rapidly in the spring. Growth may slow or stop depending on water stress and heat. If moisture is available, forage plants regrow until late summer and fall. However, the majority of the annual forage growth will occur in the spring and early summer.

The forage needs of the herd will usually increase from spring through summer as calves or yearlings grow. Some forage from the spring has to be left behind after initial grazing passes to ensure there will be forage to come back to. The grazing manager should move animals more rapidly through the paddocks when the forage is growing rapidly. One goal is to prevent animals from grazing the rapidly regrowing forage. Another goal is to trim the tops of plants to keep them vegetative and reduce seed production. Ample leaf area should be left behind to allow plants to regrow as rapidly as possible.

Animals may need to be moved every day to every seven days during rapid plant growth. When forage growth slows down in midsummer, slow the pasture rotation and allow animals to spend more time in each paddock to harvest the accumulated grass.

Paddock selection should also be flexible. Determine which paddock is the most ready for grazing, and move the stock there rather than sticking to a fixed order. The plant species present in a paddock, the timing and intensity of use in previous grazing sessions, moisture, soil type, soil fertility, slope and aspect all affect plant growth. Grazing paddocks in a different order at different times during the year allows the management of plant growth and animal utilization.

The ultimate in flexibility occurs when paddock shape and size is flexible. Improvements in electric fencing technology have made it easier to use a combination of permanent and temporary electric fences, so paddocks can be adjusted as needed.

Number of Paddocks

The number of paddocks used in a rotational system varies with management goals, landscape and personal preference. Even a couple of paddocks will increase management options and flexibility. Managers wanting to increase their production per hectare will opt for more paddocks. Some high intensity systems use large numbers of paddocks to provide a uniform, high quality feed supply. Paddocks must be large enough to supply the herd's feed requirement for the duration of their stay.

The minimum number of paddocks needed depends on the longest rest period needed and the longest grazing period desired, which usually occurs in mid to late summer. The regrowth period needed by the pasture for optimum production depends on the climate, forage species and time of year. In spring when moisture is abundant, Alberta grass-legume pastures need about 21 days to recover from grazing. This increases to 35 to 45 days in moist environments in midsummer, when forage growth slows. When moisture or other growing conditions are limiting, longer rest periods are needed. In the dry Brown soil zone, plants may need up to 12 to 18 months of rest.

In spring when plants are growing rapidly, cows will start grazing regrowth in just four to seven days, so animals should be moved relatively quickly. Later in the season, length of stay can be up to 7 to 14 days or longer and still avoid grazing regrowth.

The number of paddocks needed in a grazing system equals the number of days that a paddock will be rested, divided by the number of days it will be grazed, plus one paddock for the animals to be grazing while the other paddocks are resting.

Example:
Determining the Number of Paddocks Needed

Assumptions:
- Want a 42-day rest period after grazing
- Want a 7-day grazing period

Paddocks = (days rested/days grazed) +1
= (42 days rest / 7 days grazed) +1
= 8

Need at least 8 paddocks to provide the desired rest and grazing periods

DIVIDING INTO PADDOCKS

One goal in any grazing system is to make grazing management as simple as possible while still achieving management goals. Pastures are more easily managed when each paddock is as homogeneous as possible, consisting of similar plant species, soil and terrain. Paddocks where plant growth and maturity are uniform are easiest to manage.

Divide pastures so that similar forage areas are grouped and dissimilar areas are separated. Fence native or bush pastures apart from seeded pastures. Fence low areas separately from the uplands. Fence newly seeded pastures from old forage stands. Fence pastures with different forage species separately. Consider fencing cattle out of trees and riparian areas to increase management options.

Guidelines for Paddock Layout
- Make paddocks as square as possible (less than 3:1 length:width) to keep grazing more uniform and to accommodate fencing.
- Avoid paddocks that run from the top of a hill to the bottom, to reduce erosion. If possible, make hilltop, sidehill and bottom paddocks.
- Separate different pasture forage types into separate paddocks where possible. Try to separate native forage from tame forage.
- Fence riparian areas and treed areas separately to make them easier to manage.
- Focus on making paddocks as similar in forage productivity as possible rather than making them the same size.
- Fence south-facing slopes separately from north-facing slopes where possible since forage grows at different rates depending on aspect.

Guidelines for Lanes
- Avoid running lanes up and down slopes.
- Avoid running lanes through low or wet areas.
- Place paddock gates in the corner of the paddock nearest the water source.
- Make lanes wide enough for free movement of vehicles and easy access to paddocks.
- Make paddock gate widths equal to the lane width, so the open gate can block access to unneeded parts of the lane.
- Consider piping water to paddocks as an alternative to lanes.

Fences are an expensive part of grazing management. Perimeter fences need some substance, but internal fences should be the minimum that will keep animals in. Many people use electric fences because they tend to be cheaper and quicker to set up than other types of fencing. A single hot wire or polywire often works for a crossfence.

Electric fences are not foolproof, and managers should learn how they work before trying to use them. A good energizer and effective ground system are critical to an effective electric fence. Animals must be trained to recognize and respect the electric fence.

The biggest advantage to electric fencing for rotational grazing is the flexibility in location. Internal electric fences can and should follow land contours rather than legal boundaries. They are also easier to move if time and experience indicate a better option.

Water

Water is often the single greatest problem in developing more efficient grazing systems. Livestock need ready access to clean water for a healthy pasture system. There is a direct relationship between water intake and feed intake. Without enough water, animal gains, health and milk production are reduced.

Direct access to dugouts and ponds should be avoided to eliminate fouling the water. Water should be pumped to a trough or tank to provide clean water.

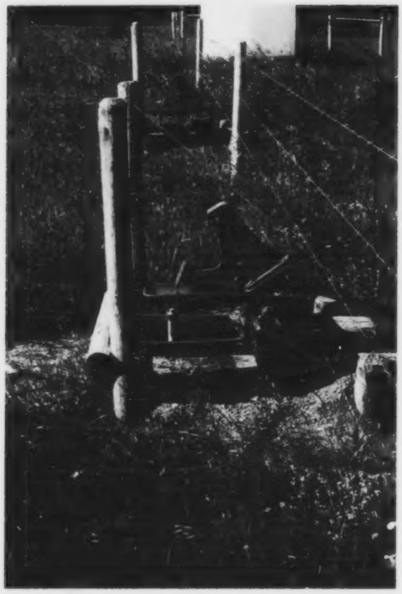
WHEN CATTLE ARE ALLOWED ACCESS TO DUGOUTS, THEY WILL MANURE IN AND AROUND THEM, WHICH CAN CONTAMINATE THE WATER SOURCE AND REMOVE NUTRIENTS FROM THE PASTURE

When moving into more intensive grazing systems, water becomes a major consideration. Ideally, water should be available in every paddock. If this is not possible, limit the distance stock have to travel to water. Animals graze most efficiently when water is less than 250 meters (820 feet) away.

As the distance to water increases, stock spend more time traveling to and loitering at the water. Forage near water is overgrazed, while more distant forage is underutilized. Manure distribution is also less even, with more concentrated near the water. High producing animals do better if they have ample, accessible water.

Well planned lanes or alleyways are often used to allow stock to travel to water. When pastures are being developed within 1.5 to 2 km of a good water and power source, it may be cheaper and more effective to develop a pasture water pipeline system. Pipeline systems offer extremely flexible alternatives for intensive rotational grazing systems. Other ways of getting water to paddocks include the following:

- water hauling
- livestock-powered pump systems
- solar-powered pump systems
- electrical pumps
- gas-powered pumps
- hydraulic ram pumps
- sling pumps



NOSE PUMP

WATER TANK

Pasture Assessment

Tame pasture productivity depends on healthy interactions between soil, plants and animals. All these components must be healthy and functioning together for optimum pasture performance. Pasture assessments solve productivity problems by breaking the soil, plant and animal interactions into pieces that are more easily monitored. Pasture assessments help managers decide how to adjust pasture management and when and how to rejuvenate a pasture. They make decision making easier by identifying strengths and weaknesses, so rejuvenation and management can be targeted to produce specific results.

Pasture assessments are used to make informed management decisions and pinpoint problems that need to be addressed. Pasture assessments help managers focus on the source of the problem rather than symptoms. Dealing with symptoms is expensive and addictive. Until the source of the problem is fixed, the symptoms keep coming back.

PASTURE ASSESSMENTS ARE USED TO MAKE INFORMED MANAGEMENT DECISIONS

There are at least four types of pasture assessments: monitoring, managing, planning and measuring. They differ in the details of the assessment and in how frequently they are done. The most frequently done pasture assessment is the monitoring assessment, which is done when cattle are moved from one paddock to another. Pastures are assessed quickly and simply, often just noting dates of moves, pasture use and carry-over, available forage, plant maturity or growth stage. The monitoring assessment often ends up as notes in a logbook or on a grazing plan.

The managing assessment is done weekly, bi-weekly or monthly depending on pasture management intensity. This assessment tracks plant growth and utilization on all paddocks rather than just the ones stock are moving out of and onto. Information collected is used to make sure the grazing plan is still accurate and to determine any adjustments needed. Notes on pasture and animal condition are compared to the written plan, so adjustments to stocking rate, grazing period, grazing sequence and rest can be made as needed.

The planning assessment is usually done annually at about the same time each year. This assessment is used to make or confirm the written grazing plan. It helps determine overall pasture productivity, tracks pasture trends, helps with troubleshooting and allows managers to pinpoint opportunities for pasture improvement. Various forms are available for working through the planning assessment.

The measuring assessment looks at pasture condition and management in detail and identifies trends over time. This assessment is usually done every five to ten years. Again, this assessment is best done at about the same time of year each time it is done, ideally at the same time as the annual planning assessment. Pasture assessment forms are an excellent starting point for this assessment, and they can be complemented by soil tests and forage clip weights. A series of fixed-point photographs of the same areas in the pasture over a number of years can show trends that may be missed in day-to-day management.

A number of tame pasture assessment tools (such as the Alberta Tame Pasture Scorecard – check Alberta Agriculture's web site) are available to managers. They tend to be similar since they measure the same interactions between soil, plants and animals. Generally, assessment tools vary mainly in precision and detail. Managers should select the form that gives the details they need for decision-making.

Managing Legume Pastures

Interest in grazing legume pastures is growing in Alberta. Legumes, especially alfalfa, are very productive over most of Alberta. Legumes provide large quantities of nutritious forage, which support high levels of animal production. Use of legume pastures has been limited by bloat risk, which may lead to large animal losses. Recently, there have been a number of new technologies introduced to manage bloat on legume pastures, including a much better understanding of what causes animals to bloat and how it can be prevented. Technologies including bloat-reduced alfalfa, boluses and additives to the water have opened opportunities for grazing alfalfa.

Most legumes are sensitive to grazing, so proper pasture management is important to increase the life of the stand and maximize animal productivity. Legume pastures are well suited to rotational grazing methods. Winterkill may result from grazing during the critical period (late July to late August) or continuous grazing, and they need a rest period of at least 28 to 35 days after grazing to stay vigorous.

Animals should be moved to the next paddock when the stand has been grazed down to 8 to 10 centimeters in height. Rotational grazing is also important in managing bloat in livestock. High stock densities increase competition for the plants and reduce the likelihood of one animal selectively grazing only the tops of plants. Animals are forced to eat more fibrous stems as well as leaves.

GRAZING ALFALFA

Legumes like alfalfa and clovers can cause frothy bloat in ruminants. Bloat occurs because legumes are broken down rapidly in the rumen, 5 to 10 times more quickly than grasses. This rapid rate of digestion allows animals to eat greater quantities of forage, enabling the high productivity of cattle on legume pastures. It also contributes to bloat problems. Soluble proteins from the legumes combine with fermentation gases to produce thick foam that accumulates in the rumen. The foam prevents the animal from releasing gases, leading to bloat.

Not all legumes cause bloat in ruminants. Sainfoin and birdsfoot trefoil contain higher levels of tannins, which are natural bloat inhibitors. When enough tannins are present in feed, they prevent the development of the foam that causes bloat. Having 10 to 20 per cent sainfoin in an alfalfa pasture reduces the bloat risk when grazed.

HIGH BLOAT RISK FACTORS

Forage maturity is one of the most significant contributors to pasture bloat. The highest risk of bloat occurs when legumes are in the vegetative or pre-bud stage. As plants mature and become more fibrous, the risk of bloat declines. Livestock are twice as likely to bloat when young plants 20 to 25 centimeters tall are grazed rather than when plants are 50 to 75 centimeters tall. Morning dew or rain on plants increases bloat risk since the water tends to speed up rate of digestion. Bloat risk also increases after frost because plant cells burst and become more digestible.

RUMEN CONTENTS FROM AN ANIMAL WITH FROTHY BLOAT

REDUCING BLOAT ON LEGUME PASTURES

- Include non-bloating legumes like cicer milkvetch, sainfoin and birdsfoot trefoil in areas where they are adapted.
- Use low bloat or reduced bloat alfalfa varieties. AC Grazeland was developed to have a slower initial rate of digestion, which reduces the potential for bloat.
- The use of 40 to 50 per cent grass in a legume mixture reduces the incidence of bloat.
- Use products or supplements to manage bloat.
- Never move hungry cattle onto legume pastures. Animals should always be full when introduced to a new pasture. Avoid moving cattle in the morning before they have eaten their fill. Move cattle before they have eaten everything available in the paddock they are on and are hungry.
- Move animals into new pastures in the afternoon, when plants are dry.
- Feed good quality hay to fill the rumens before starting cattle on legume pastures and when the bloat risk increases.
- Maintain a uniform and regular intake of legume forage. Once cattle are introduced to the legumes, every effort should be made to maintain the herd on the legume pasture.
- Check animals regularly, initially at least twice a day. Main grazing periods tend to be shortly after sunrise and early in the evening. Bloat usually occurs 1 to 1.5 hours after a main grazing period, so checking at these times will improve the odds of spotting a problem early.
- Some animals are chronic bloaters. These should be removed from the pasture.
- Watch animals grazing vegetative alfalfa or other bloat-causing legumes carefully. Grazing after the bud stage reduces the risk of bloat.

Grazing legume pastures offers many advantages, including improved pasture and animal performance. Although good management and bloat reduction products will go a long way to reducing the risk of bloat, they do not completely eliminate the occurrence of bloat on alfalfa and clover pastures. Increased pasture and animal management are the costs associated with the increased productivity and profitability of grazing legume pastures.

Managing Annual Pastures

Annual and winter annual crops add flexibility to livestock operations by providing supplemental or emergency pasture. They produce pasture in the same growing season that it is needed, which provides an opportunity to supplement forage production. They also maintain the pasture base while perennial pastures are rested or rejuvenated or add flexibility to the livestock operation. Annuals are productive in late summer and early fall when perennial forages may need to be rested. However, annual pastures are generally more expensive than perennial pastures as they must be established every year, and production is very dependent on precipitation and soil fertility (see the Annual Forages section).

Spring cereals, especially oats and barley, are widely used for silage and greenfeed production in Alberta. They generally produce more forage than perennial crops. However, spring cereals are less desirable for pasture because they produce most of their forage early in the growing season. Since this is the same time that perennial pastures are most productive, they do not complement perennial pastures well. In addition, spring cereals produce stems and seed heads early and are hard to maintain in a vegetative state for grazing. Once these crops head out, palatability and quality decrease.

Winter cereals perform well for pasture, since they provide quick available forage and offer flexibility in grazing periods to complement existing pasture systems. Winter cereals seeded in the spring are productive through the summer. Winter cereals need to be vernalized (exposed to cold temperatures) to produce seed heads, so when spring seeded, these crops remain vegetative throughout the growing season and produce only leaf material. This feature makes them easier to manage for summer grazing in the year of seeding.

GRAZING WINTER CEREALS

Winter cereals regrow well after grazing and are well suited for use in rotational grazing or strip grazing systems. Grazing should begin once the crop is 15 centimeters tall or when the drill rows have filled in and are no longer visible. Under good growing conditions, a rotational grazing method using a one-week grazing period followed by three to four weeks of rest has been the most productive.

Fall rye in central Alberta will generally be ready to graze two weeks earlier than winter wheat while winter triticale will fall between these two. These crops make excellent summer pastures and will maintain their growth and quality well into the fall, making them ideal for extending the fall grazing period. Livestock gains on winter cereals can be very high, especially later in the growing season when forage quality on perennial pastures is dropping. Fall rye and winter triticale tend to be more productive in the fall than winter wheat.

Grazing fall-seeded winter cereals is also common in Alberta. Winter cereals can be grazed in the fall as soon as they have enough top growth, or they can be overwintered and used as early spring pasture. Fall rye is the hardiest of the winter cereals, and the most disease resistant, and should be the first choice for early spring pasture for much of Alberta.

Fall-seeded winter cereals should be seeded by August 15 to ensure enough forage is available for fall grazing and to ensure adequate winter hardiness and winter survival. Grazing can begin when there is about 15 centimeters of top growth. Winter cereals will stay green and continue to grow late in the fall, until it snows.

Fall-seeded winter cereals start growing very early the following spring, providing an opportunity to extend the grazing season in the spring before perennial pastures are ready. Spring grazing of fall-seeded winter cereals needs careful management to prevent or reduce the number of tillers going to seed. Once seed heads appear, plant regrowth is greatly reduced and palatability decreases. Rotational grazing with high stock densities helps keep the stand vegetative longer, producing more pasture. Grazing winter cereals in the fall tends to reduce their vigour and increases the risk of winterkill. If the goal is early spring pasture, it is best to avoid grazing the crop in that area the previous fall.

Mineral deficiencies are more likely to occur in livestock when grazing annual pastures. Livestock grazing annual pastures should have access to a complete mineral mix. Consult with a livestock nutritionist to determine the necessary minerals. Livestock may suffer from nitrate poisoning if annual pastures have been fertilized with high levels of nitrogen fertilizer or manure. Stress from drought, hail or frost may increase nitrates in plants to toxic levels.

MINERAL FEEDER

Winter cereals are high quality forage and are high in protein and low in fiber. This feature may cause diarrhea when livestock are grazing the pasture. Providing straw or mature hay as a fiber source while the animals are grazing will reduce the digestive problems.

Annual crops such as Italian ryegrass, brassicas and millets can be used for pastures as well (see Annual Forages section). Ryegrass should be managed much the same as winter cereals when used for pasture. Other crops may need special management.

Extending the Grazing Season

Many Alberta managers are extending the grazing season beyond the growing season. Grazing is cheaper than harvesting and feeding stored feeds. Extending the grazing season reduces or eliminates the costs of harvesting, hauling and feeding stored feed, manure removal and may reduce machinery overhead expenses. Extending the grazing season does require adequate acres and management to produce a stockpiled pasture that is high enough in quantity and quality to meet animal requirements.

STOCKPILING PERENNIAL FORAGE

Stockpiling or banking perennial forage means management is adjusted to allow forage to grow and accumulate in the field to be used at another time. Management is required to ensure adequate quantity and quality of forage is available when it is needed. Typically, forage regrowth after spring grazing is left to grow until late fall, early winter or spring when it is needed.

WINTER GRAZING STOCKPILED PERENNIALS

Grazing needs for stockpiled forage should be planned well in advance, usually the winter or spring before the forage will be needed. In its simplest form, hay acres can be diverted into pasture production. However, managers may also manage specific paddocks within their pasture system or establish new pastures specifically for stockpiling. A pasture with stockpiled forage needs to provide access to dependable winter water or snow supply, appropriate forage species, soil nutrients and timing of grazing and rest periods to ensure appropriate forage will be available. Crusted or packed snow limits the availability to the grazing animal (also see the Swath Grazing section).

While any forage species can be stockpiled, some species are better than others. The best species for stockpiling tend to be perennial grasses that have or can be managed to have short shoots through the summer and fall. Plants with basal leaves provide higher quality feed in the winter than plants with longer stems that expose the leaves to weathering. Forages like creeping red fescue and meadow bromegrass stockpile well. Forage quality will stay higher under the snow than above it.

Grasses are generally better than legumes for stockpiling because they retain more leaves into the fall and winter. Alfalfa can be stockpiled for grazing in September and October, but later than that, it usually loses a lot of leaves. Cicer milkvetch and clovers also show potential for stockpiling in the fall.

Table 38 shows the dry matter yields of several forage species managed for stockpiled grazing at Lacombe, Alberta. The more productive species like meadow bromegrass, smooth bromegrass and timothy produced the most accumulated forage. Most species reached maximum yields by mid-September after a nine-week rest period, although timothy and crested wheatgrass continued to increase production. On average, 25 per cent of the accumulated forage was lost over the winter with alfalfa having the highest yield loss (43 %), most of which was leaf material.

Forage quality depends on plant growth stage and that remains true for stockpiled pasture. Forages that are vegetative going into fall and winter will be higher in quality than forages that are in the elongation stage.

To ensure high quality forage for stockpiled grazing, graze or cut the stand once early in the growing season and allow the regrowth to stockpile for later use. At Lacombe, with good moisture and high fertility levels, meadow bromegrass rested from August 1 provided high quality and high yielding pasture for stockpiling. In drier areas, areas with a shorter growing season or with moderate fertility levels, the last clip should be done by July 1 to July 15 to allow adequate forage volume to accumulate. While low yielding stands can be readily grazed before it snows, after it snows, forage volume becomes more critical. It costs livestock energy to graze through the snow, and they need to be able to find sufficient forage to justify the effort of grazing.

Forage quality decreases as the regrowth period gets longer since the plants are more mature and old leaves start to die. Stockpiled forages generally can meet the nutritional needs of beef cows in mid-pregnancy in the early and late fall. However, by spring, some forage quality has been lost. By spring, stockpiled forages do not meet the nutritional requirements of beef cows in late pregnancy.

TABLE 38
Dry matter yields of stockpiled forage at three cutting times and dry matter losses over winter in Lacombe, Alberta[1]

Yield on Harvest Date (kg/ha)				
Species	**Mid-September**	**Mid-October**	**Mid-April**	**% Loss October – April**
Alfalfa	5,560	5,040	2,890	43
Meadow Bromegrass	5,830	5,780	4,520	22
Smooth Bromegrass	6,840	6,100	4,110	33
Orchardgrass	5,630	5,640	4,380	22
Timothy	6,530	7,040	6,840	3
Crested Wheatgrass	5,960	6,790	4,440	35
Kentucky Bluegrass	4,490	4,340	4,040	7
Creeping Red Fescue	4,900	5,060	3,460	32

3-year average – 1998, 1999 and 2000
Regrowth following a mid-July harvest

[1] Baron, V.S., et al. 2004. Stockpiling potential of perennial forage species adapted to the Canadian western prairie parkland. Agron. J. 96:1545-1552

Table 39 shows the nutritional value of stockpiled forages harvested in mid-September, mid-October and mid-April from a trial in Lacombe. Alfalfa had the largest quality losses over the winter, which can be attributed to the large loss of leaves, which is typical of the crop. Meadow bromegrass, creeping red fescue and crested wheatgrass had the least amount of digestibility loss, with meadow bromegrass maintaining a digestibility of over 50 per cent into the spring. Of the grasses, creeping red fescue had the lowest acid detergent fiber (ADF) levels and smooth bromegrass the highest. ADF is the highly indigestible portion of the forage.

Based on yield and the ability to maintain quality, meadow bromegrass was very good for stockpiling for fall and spring grazing. Creeping red fescue was lower yielding but had good forage quality and maintained its quality better than the other species in the trial. Alfalfa and smooth bromegrass did not have sufficient quality for spring grazing and should be used for fall grazing only.

Some native forage plants cure on the stem and remain available for grazing in the fall and winter. To get adequate forage quantity for grazing these pastures, they often need to be rested through most or all of the growing season to allow forage to accumulate. The forage available in the fall is generally mature, with low nutritional value. Native forage cured on the stem will generally meet the nutritional requirement of a dry beef cow early in the second trimester of pregnancy. Usually, supplementation on pasture is required to make more than short-term use of native pasture in the fall and winter.

Tame forages, especially in the moister parts of the province where greater production occurs, should be stockpiled in a vegetative state so that forage quality is higher. Well managed meadow bromegrass or creeping red fescue stockpiled pasture should meet the nutritional requirements of dry beef cows through the second trimester without supplementation. Stockpiled forage should be tested to ensure the nutritional needs of the grazing livestock are met.

TABLE 39
Nutritional value of stockpiled forages at Lacombe, Alberta[1], when harvested in the early fall, late fall and spring

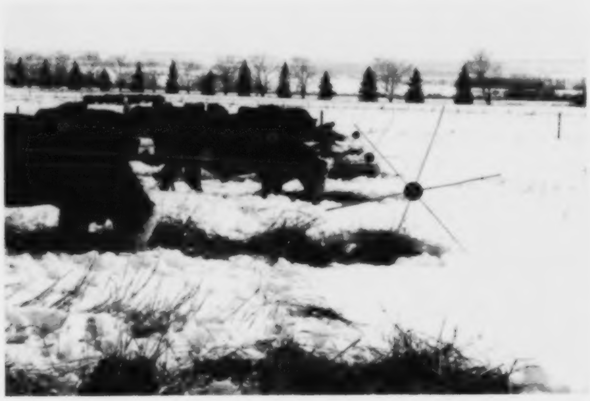
Species	Protein (%)			ADF (%)			NDF (%)			IVDOM (%)		
	Harvest Date											
	mid-Sept	mid-Oct	mid-Apr	mid-Sept	mid-Oct	mid-Apr	mid-Sept	mid-Oct	mid-Apr	mid-Sept	mid-Oct	mid-Apr
Alfalfa	14.9	12.2	10.7	39.8	39.1	60.8	50.5	55.1	80.6	59.3	56.4	34.8
Meadow Bromegrass	10.2	8.0	9.9	36.2	35.9	45.2	59.8	57.2	72.2	64.8	57.9	50.5
Smooth Bromegrass	8.7	6.7	9.6	36.2	38.2	49.2	58.9	62.7	77.8	58.3	55.3	37.3
Orchardgrass	10.9	7.9	10.5	36.2	35.8	44.4	59.9	59.0	72.9	61.2	57.2	42.7
Timothy	8.0	7.1	9.8	33.9	34.8	45.3	57.3	58.9	73.9	61.0	55.8	40.9
Crested Wheatgrass	10.6	7.5	7.4	33.0	33.1	40.6	57.4	55.7	70.2	62.8	58.3	47.5
Kentucky Bluegrass	11.1	10.3	10.7	35.8	35.7	42.2	64.4	61.1	71.6	59.1	52.8	44.0
Creeping Red Fescue	10.6	8.2	10.0	30.2	27.9	36.9	55.1	49.9	64.4	62.9	59.7	49.5

3-year average – 1998, 1999 & 2000
Regrowth following a mid-July harvest
ADF – Acid Detergent Fiber; NDF – Neutral Detergent Fiber; IVDOM – Invitro Digestible Organic Matter

[1] Baron, V.S., et al. 2004. Stockpiling potential of perennial forage species adapted to the Canadian western prairie parkland. Agron. J. 96:1545-1552

SWATH GRAZING

Swath grazing is an effective way to extend the grazing season with annual forages. Annual forages are seeded in mid-May to mid-June and swathed from late August to mid-September when the crop reaches the soft to late dough stage and before killing frosts. The swaths are left in the field for the cattle to graze during the fall, winter and/or spring. Swath grazing provides sufficient nutrients for dry, mature beef cows that are in reasonable body condition. Animals requiring higher nutrition may need to be supplemented to allow them to make use of the swathed forage.



ELECTRIC FENCE USED TO CONTROL SWATH GRAZING

MANURE DISTRIBUTION ON SWATH GRAZED PASTURE

Barley and oats are the most common crops used for swath grazing. High yielding grain varieties generally produce high forage yields. Late maturing forage varieties may enhance forage quality at the time of swathing.

Crops should be seeded from mid-May to mid-June. Research has shown that forage yields are maximized when crops are seeded in May and decrease as seeding date becomes later (see Figure 39). The earlier a crop is seeded, the earlier it will need to be harvested. Time of usage should be considered to determine when to seed. The goal is to swath the crop in the fall, before frost, when the crop has reached the early heading to soft dough stage to provide high quality forage. Swaths should lie on top of the stubble and be as large, narrow and deep as possible to reduce wastage.

Good grazing management is critical for effective swath grazing. Controlling cattle access to the swaths is important to minimize waste and maintain forage quality. Portable electric fences and animals trained to respect the fences work well to restrict animal access. By restricting access, feed utilization is improved, and wastage and trampling is reduced.

Animals will graze the seed heads first and the straw last. Limiting access will force the animals to clean up the straw before getting new swaths to graze. A three-day strip of swaths will reduce wastage while maintaining a high quality diet. Forage quality will also remain higher as swaths can be left undisturbed until grazed.

With any extended grazing system, field selection, animal health and management all influence the effectiveness of the system. For best results, select a field that has the following:

- where animals can be easily monitored and removed if not doing well
- where a water system is available if snow is unavailable or unsuitable as a water source
- protection from the wind – grazing animals, whether grazing swaths or stockpiled forage, spend more time and energy eating and need shelter from adverse weather
- where severe snow drifting and accumulating will not limit access to feed
- where supplemental feed can be provided to animals if necessary
- where wildlife problems can be avoided or controlled

CORN CAN BE USED TO EXTEND THE GRAZING SEASON

CORN GRAZING

Corn is used as a grazing crop and has been developed as either a grain or silage crop. However in most areas of the prairies, there are not sufficient "corn heat units" (CHU) (see Figure 41) to grow corn as either a grain or silage crop. Nor are there enough CHU's in much of the prairies to produce the high yields associated with corn for silage.

Without sufficient heat units, corn yields are generally not much better than spring cereals. The grain portion of the corn adds around 50 per cent of the yield to the silage mix. When the grain is not sufficiently filled, the yields are drastically reduced.

There is some value to corn as a crop for fall or winter grazing. The quality of the corn leaves and stalks are high. The corn stands erect and can be grazed easily if electric fencing is used to limit livestock access, which will reduce wastage by ensuring that the stalks are better utilized. In years where there is some grain production, limiting livestock access prevents problems associated with grain overload as the livestock will be forced to eat not only the cobs with the grain, but the leaves and stalks as well.

Growing the corn variety requiring the least number of heat units will ensure as much growth and maturity as possible in areas of low corn heat units. New herbicide tolerant varieties reduce the problems associated with the good weed control needed to grow corn. However, the cost of growing and utilizing corn for winter grazing makes this crop less attractive than growing cereals for swath grazing.

HARVESTING HIGH QUALITY FORAGE

Harvesting High Quality Forage

Forage quality is ultimately measured by animal performance when the forage is consumed as harvested feed or grazed as pasture. This performance is influenced by total nutrient intake, which is in turn related to dry matter intake by the animal and the digestibility of the forage.

Forage intake is the amount of forage the animal will consume, and digestibility is the amount of forage the animal digests from it. Forage intake is affected by the palatability of the forage (i.e. flavor, odor, texture, etc.), any toxic or anti-quality elements in the forage (i.e. alkaloids, molds, weeds, etc.) and the neutral detergent fiber (NDF) level of the forage. The digestibility of the forage will be affected by the nutrients (mostly the non-fibrous content) and the acid detergent fiber (ADF) levels in the forage.

Some common terms used in determining and measuring forage quality:

- **Acid Detergent Fiber (ADF)**
  The highly indigestible portion of the forage (lignin, cellulose, silica) is called acid detergent fiber. It is generally used to calculate digestibility and energy. Forages with a high ADF level have a lower digestibility and lower energy than forages that have low levels of ADF.
- **Neutral Detergent Fiber (NDF)**
  The indigestible and slowly digestible components (cellulose, hemicellulose, lignin and ash) in the cell walls of the plant are called neutral detergent fibers (NDF). This is a more complete measure of fiber in the forage, and the NDF levels are always higher than ADF. NDF is a good indicator of the potential intake of forage; as NDF increases, intake decreases.
- **Crude Protein**
  The proteins are made up of amino acids. Protein is determined by measuring the nitrogen in the forages and multiplying by 6.25. Plant proteins are used by the animal to produce animal proteins (e.g. meat and milk).
- **Digestibility**
  Proportion of the forage digested by the animal. The digestibility is generally expressed as a per cent (%). Digestibility may be expressed as digestible dry matter (DDM), which is the forage dry weight minus the feces dry weight. In vitro digestibilities are determined in a laboratory using rumen microflora in a test tube.

Factors Affecting Forage Quality

MATURITY

The stage of maturity of the forage is the single most important factor influencing the intake and digestibility of the forage. Legumes and grasses are low in fiber and high in digestibility in the vegetative stage, and as they mature, they decline in quality (Figure 77 shows alfalfa yield and digestibility as it matures and Table 40 shows maturity effects on quality in smooth bromegrass).

As the plant matures, forage yield increases, mainly due to stem production, with very little increase in leaves. Maturity reduces the leaf-to-stem ratio and causes a decline in digestibility. The digestibility and protein concentration of the leaves and stems decline as the plant tissue ages. Stems are lower in quality than leaves (Table 41). As plants mature, stem quality declines at a faster rate than leaf quality. There is an increase in whole plant fiber levels, both ADF and NDF, which reduce digestibility and intake. There is also a decrease in nutrients such as proteins and plant sugars. Table 42 shows how stage of growth at harvest of grasses and legumes affects total digestible nutrients (TDN) and animal intake.

As the grass or legume matures, not only does the animal eat less of the forage, the digestibility of the forage the animal does eat is decreased. These changes are mainly due to the increase in the volume and percentage of stems in the forage. Legume leaves decline in quality much less than grass leaves and therefore maintain quality much better than grasses as they mature. As legume-grass forage mixtures mature, they maintain their quality better than grass grown alone.

FIGURE 77
Alfalfa yield and quality by growth stage

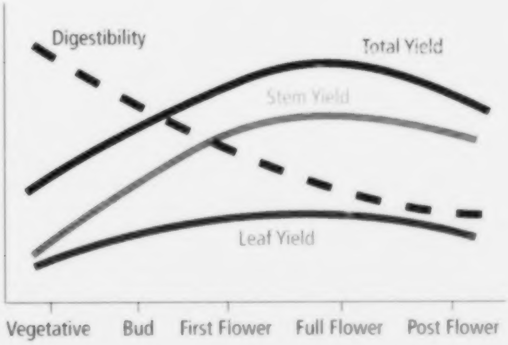


TABLE 40
Digestibilities of smooth bromegrass as affected by maturity

Growth Stage	% Crude Protein	% ADF	% NDF	% Digestibility
Vegetative	20.2	20.9	36.8	67.2
Jointing/Stem Elongation	15.8	26.0	40.7	63.1
Boot	11.3	29.4	48.3	59.5
Early Heading	10.2	33.7	54.8	54.6
Flowering	7.4	35.8	58.6	48.5
Milk	6.1	36.8	57.0	47.1
Dough	5.4	36.9	59.8	42.4

Adapted from Freebee et al 1972. North Dakota Farm Research 30:3-7. Smith, D., Bula, R.J. and Walgenbach, R.P. Forage Management 5th edition pp 216

TABLE 41
Alfalfa quality

Leaves

- 18-28% Neutral Detergent Fiber
- 12-20% Acid Detergent Fiber
- 22-35% Crude Protein

Stems

- 35-70% Neutral Detergent Fiber
- 30-55% Acid Detergent Fiber
- 10-20% Crude Protein

Ball et al. 2001. Understanding Forage Quality. American Farm Bureau Federation Publication 1-01, Park Ridge, IL

TABLE 42
Feeding value of forages as influenced by stage of growth at harvest

		Crude Protein %		Intake
Vegetative	63	15	21	3.0
Boot or Bud	57	11	16	2.5
Bloom	50	7	11	2.0
Mature	44	4	7	1.5

TDN – total digestible nutrients

Fisher, L.J. 1980. Agassiz Agriculture Canada Research Station

FIGURE 77
Alfalfa yield and quality by growth stage

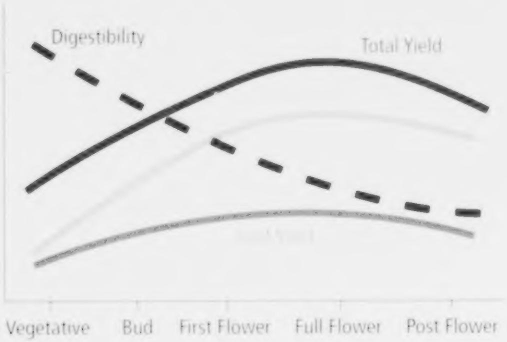


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TABLE 42
Feeding value of forages as influenced by stage of growth at harvest

		Crude Protein %		Intake
	TDN %	Grass	Legume	% of Bodyweight
Vegetative	63	15	21	3.0
Boot or Bud	57	11	16	2.5
Bloom	50	7	11	2.0
Mature	44	4	7	1.5

TDN – total digestible nutrients

Fisher, L.J. 1980. Agassiz Agriculture Canada Research Station

PLANT SPECIES

Legumes are generally higher in protein and lower in fiber concentrations than grasses (Table 43). There are quality differences between species as well. Baron and others (Table 44) looked at the common cool-season grasses, and in central Alberta, found not only yield differences but differences in crude protein, fiber levels and ultimately digestibility. Table 45 is a 10-year average analysis of hay tested for quality in Alberta from 1984 to 1994. These values are actual values of feeds being fed during that period.

The quality of grass hay or pastures can be improved with the addition of legumes in a mixture, where the legumes increase the protein and reduce the fiber levels. Plant breeders have been selecting for quality differences between crop varieties, primarily by increasing the leaf-to-stem ratio.

Multifoliates in alfalfa have been a trait that has been selected for that has met with limited success. The multifoliate trait increases the number of leaflets from the typical trifoliate having 3 leaflets to the multifoliate having 5 to 11 leaflets. This increase in leaflets will increase the leaf-to-stem ratio to increase the plant quality. There is variability in the varieties in their expression of this trait, and there may not be sufficient multifoliate leaflets on the alfalfa to have an effect on the quality.

TABLE 43
Forage quality of alfalfa and timothy components of a mixture

Species	% Crude Protein	% ADF	% NDF
Alfalfa	15.8	34.2	49.0
Timothy	9.5	37.5	65.6

Collins 1988. Composition and fiber digestion in morphological components of an alfalfa-timothy sward. Animal Feed Science and Technology. 19:135-43

TABLE 44
Quality differences of cool-season grasses grown in central Alberta[1] when cut for hay

Species	DM Yield (T/ha)	Leaf:Stem Ratio	% CP	% ADF	% NDF	% IVDOM
Meadow Brome	6.5	0.5	11.1	31.6	61.7	63.8
Smooth Brome	7.8	0.3	11.3	33.1	64.4	57.0
Hybrid Brome	6.5	0.3	12.4	32.5	63.7	62.4
Meadow Foxtail	4.2	0.5	13.8	28.9	63.9	61.5
Orchardgrass	4.7	0.9	13.2	29.8	62.0	65.0

[1] Average of 2 years

Baron et al. 2000. Leaf and stem mass characteristics of cool season grasses grown in the Canadian Parkland. Agronomy J. 92:54-63

TABLE 45
Ten-year average analyses of Alberta feeds[1] 1984 – 1994

Species	% Protein	% ADF
Alfalfa	18.1	31.9
Alsike Clover	15.1	34.9
Red Clover	14.3	37.7
Cicer Milkvetch	20.3	28.8
Smooth Brome	9.8	34.8
Reed Canarygrass	9.7	34.5
Meadow Foxtail	11.9	33.2
Orchardgrass	12.8	31.9
Crested Wheatgrass	8.1	36.6

[1] Data based on hay samples submitted for analyses and is a representation of the hay samples in Alberta.

A.I.H. Suleiman et al. 1995. Alberta Agriculture and Rural Development

SOIL NUTRIENTS

Soil nutrients can have a positive or negative affect on forage quality depending on the levels present. Nitrogen fertilizer applications on grasses will generally increase yield, and high rates of nitrogen fertilizer will increase crude protein levels (see Fertility section, Table 27). Nitrogen may also have a negative effect on grasses if environmental conditions such as drought or frost affect plant growth and increase nitrate accumulation to toxic levels. Fertilizing grasses with nitrogen also tends to reduce soluble carbohydrate concentrations and increase water content, but there is generally very little effect on digestibility.

Sufficient soil phosphorous levels or the addition of phosphorus to deficient soils will promote legume production in legume grass mixtures, which will increase overall forage quality. Grasses generally have lower phosphorus concentrations than legumes, and forages grown in soils with low phosphorus levels may be deficient in phosphorus.

If soil potassium levels are high or excessive, the potassium content in forages may also be excessive. This situation can occur when manure is applied continuously to forage crops at high rates. The potassium level of the forage should be tested to ensure a balanced ration is being fed. Forages containing high levels of potassium can cause milk fever in dairy cows. Potassium also affects the uptake of calcium, magnesium and sodium, which can result in grass tetany.

TEMPERATURE

Temperature has an effect on forage quality. Cool-season forage species (smooth bromegrass, timothy, fescues, etc.) have an optimal temperature range of approximately 15 to 25° C for growth. As temperatures exceed this level, carbohydrate concentrations decrease, and at temperatures below this level, they accumulate in the plants. Fiber levels may also increase as growing temperatures increase. Alfalfa is less affected by higher temperatures (30 - 35° C) than other cool-season legumes and grasses.

During the day, plants accumulate carbohydrates while at night, they consume them through respiration. Forage quality is higher in the late afternoon than in the morning under good growing conditions. A slow dry down period before baling extends the time during which plant respiration occurs, resulting in lower energy levels in the hay. In Alberta, where the dry down period is longer, the benefit of cutting in the afternoon to capture the increase in forage quality is reduced.

HARVEST AND STORAGE

In Alberta, forage is harvested and stored to be used during the winter feeding period, during periods of drought and, in some cases, for convenience. The forage can be stored as dry hay in small square bales, large square bales, large round bales, stacks, as chopped silage in silos or bunkers or as bale silage.

HAY SHED USED TO REDUCE WEATHERING LOSSES

Nutritive losses during forage harvest may significantly affect the final quality of forage. Deterioration in the quality of feed occurs as a result of plant respiration, rain and from leaf losses due to overdrying and overhandling of the forage.

As the forage dries down, the leaves in particular become brittle and can shatter or break off. Excessive leaf losses occur when raking and picking up overdried hay. Leaves contain a very high proportion of the total digestible nutrients of hay. Alfalfa leaves contain two to three times more crude protein, but only one-third to one-fourth as much fiber as stems. In legumes, the leaves contain approximately 70 per cent of the protein of the entire plant. Most of the dry matter loss that results from handling overdried hay is the consequence of leaf loss, so the actual loss in total digestible nutrients is larger than the actual weight loss indicates.

In Table 46, Rotz and others give the dry matter losses between the different forage harvesting operations. Since conditions are variable, a range of potential losses is given, along with an average dry matter loss. Rotz also indicates the change in nutritional qualities, protein, fiber and digestibility, when these losses occur during the harvesting operation.

Some haying operations result in higher yield loss than others, and some operations have higher quality losses than others, depending on the moisture content of the hay and the aggressiveness of the haying operation. If the dry matter losses are whole plant losses, there will be very little quality loss; whereas, if the dry matter losses are leaf losses, there will be larger quality losses. Legume harvest losses are greater than grass harvest losses, because legume leaves detach easily when dried and they have greater nutrient percentages than grasses.

POOR MANAGEMENT CAN CAUSE HIGH LEAF LOSSES IN ALFALFA

TABLE 46
Typical dry matter (DM) losses and nutrient changes during hay harvest and storage operations

	DM Loss (% DM)		Change in Nutrient Concentration (Percentage Unit)		
Legume Crops	**Average**	**Range**	**CP[1]**	**NDF[2]**	**DDM[3]**
Mowing	1	1-3	-0.4	0.6	-0.7
Mowing and Conditioning	2	1-4	-0.7	1.2	-1.4
Tedding	3	2-8	-0.5	0.9	-1.2
Swath Inversion	1	1-3	0.0	0.0	0.0
Raking	5	1-20	-0.5	1.0	-1.2
Baling					
Small Rectangular	4	2-6	-0.9	1.5	-2.0
Large Rectangular	3	1-4	-0.7	1.0	-1.5
Large Round	6	3-9	-1.7	3.0	-4.0
Hay Storage					
Inside	5	3-9	-0.7	2.1	-2.1
Outside	15	6-30	0.0	5.0	-7.0
Grass Crops					
Mowing	1	1-2	0.0	0.0	0.0
Mowing and Conditioning	1	1-2	0.0	0.0	0.0
Tedding	1	1-3	-0.2	0.4	-0.4
Swath Inversion	1	1-3	0.0	0.0	0.0
Raking	5	1-20	-0.3	0.5	-0.6
Baling					
Small Rectangular	4	2-6	-0.5	0.9	-1.0
Large Rectangular	3	1-4	-0.4	0.7	-0.8
Large Round	6	3-9	-1.0	1.8	-2.0
Hay Storage					
Inside	5	3-9	-1.3	3.2	-1.8
Outside	12	5-22	0.0	8.0	-4.8

[1] CP = Crude Protein [2] NDF = Neutral Detergent Fiber [3] DDM = Digestible Dry Matter

Note: Dry matter losses may be whole plant or leaf. Dry matter leaf losses will affect yield and quality whereas dry matter whole plant losses will mainly affect yield.

Source: Adapted from Rotz and Muck, 1994. Rotz, C. A. and Shinners, K.J. Hay Harvest and Storage Chapter 39 p. 604. Forages - The Science of Grassland Agriculture Vol. II. 6th Edition. Barnes et al (editorial authorship) Blackwell Publishing

Some haying operations result in higher yield loss than others, and some operations have higher quality losses than others, depending on the moisture content of the hay and the aggressiveness of the haying operation. If the dry matter losses are whole plant losses, there will be very little quality loss; whereas, if the dry matter losses are leaf losses, there will be larger quality losses. Legume harvest losses are greater than grass harvest losses, because legume leaves detach easily when dried and they have greater nutrient percentages than grasses.

POOR MANAGEMENT CAN CAUSE HIGH LEAF LOSSES IN ALFALFA

TABLE 46
Typical dry matter (DM) losses and nutrient changes during hay harvest and storage operations

	DM Loss (% DM)		Change in Nutrient Concentration (Percentage Unit)		
Mowing	1	1-3	-0.4	0.6	-0.7
Mowing and Conditioning	2	1-4	-0.7	1.2	-1.4
Tedding	3	2-8	-0.5	0.9	-1.2
Swath Inversion	1	1-3	0.0	0.0	0.0
Raking	5	1-20	-0.5	1.0	-1.2
Baling					
Small Rectangular	4	2-6	-0.9	1.5	-2.0
Large Rectangular	3	1-4	-0.7	1.0	-1.5
Large Round	6	3-9	-1.7	3.0	-4.0
Hay Storage					
Inside	5	3-9	-0.7	2.1	-2.1
Outside	15	6-30	0.0	5.0	-7.0
Mowing	1	1-2	0.0	0.0	0.0
Mowing and Conditioning	1	1-2	0.0	0.0	0.0
Tedding	1	1-3	-0.2	0.4	-0.4
Swath Inversion	1	1-3	0.0	0.0	0.0
Raking	5	1-20	-0.3	0.5	-0.6
Baling					
Small Rectangular	4	2-6	-0.5	0.9	-1.0
Large Rectangular	3	1-4	-0.4	0.7	-0.8
Large Round	6	3-9	-1.0	1.8	-2.0
Hay Storage					
Inside	5	3-9	-1.3	3.2	-1.8
Outside	12	5-22	0.0	8.0	-4.8

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Note: Dry matter losses may be whole plant or leaf. Dry matter leaf losses will affect yield and quality whereas dry matter whole plant losses will mainly affect yield.

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Hay Harvesting Systems

Forage losses during cutting are normally low, but the choice of cutting equipment has a *major effect* on subsequent leaf loss. Windrowers or mower conditioners are the most suitable harvesting machines. The use of a hay conditioner results in more uniform drying of both stems and leaves, which decreases drying time and normally results in lower weathering losses.

The dry matter yield and the quality of the forage after cutting will not improve; there is only a decrease in dry matter and nutritive value from the time forage is cut until it is fed to the livestock. Losses will occur during cutting, by plant respiration after cutting, leaching, by swath manipulation (raking, tedding), baling or silaging, storage and feeding. Each step of the process affects the quality of the forage negatively. The challenge when harvesting forage is to minimize the losses at each step of the process.

MOWER CONDITIONER

ROUND BALER

Most losses are dry matter losses. The dry matter losses can be nutrients such as sugars and carbohydrates, but the largest losses tend to be leaves and stems. The potential for losses increases as the forage dries and the leaves become more brittle and breakable. Most yield losses occur from leaf loss, and since the leaves are higher in quality than stems, most quality losses occur when the leaves are lost.

Forages are 80 per cent or higher in moisture in the vegetative stage, and as they mature, the moisture levels decrease. Most forages are harvested somewhere between 70 to 85 per cent moisture. For silage production these forages must be wilted to 55 to 68 per cent to ensure proper ensiling. For hay production, the forage must be dried to 15 to 20 per cent moisture, depending on bale size, to ensure storage without spoilage. Forages baled with 20 to 30 per cent moisture require chemical treatments to stabilize them. Plastic-wrapped bale silage can be fermented when forages are 40 to 55 per cent moisture.

Plant respiration continues to occur after cutting. Respiration losses are highest in fresh cut forage and decline as the crop dries. As the moisture level falls below 40 per cent, the amount of respiration is low. These losses can be 2 to 3 per cent of the dry matter.

Losses due to rain are greatest with the higher quality forages. The losses result from leaching of soluble nutrients, respiration, leaf losses and mold. The dry matter losses decrease the quality of the forage by removing the more digestible constituents, leaving a higher concentration of non-digestible dry matter. This result is shown by neutral detergent fiber (NDF) percentage increases and digestibility (in vitro dry matter disappearance or IVDMD) decreases (Table 47).

TABLE 47
Effects of leaching on the composition of alfalfa hay

Alfalfa Constituent	Fresh Herbage	Cured Hay	Leached Hay
% Protein	17.9	17.1	16.4
% ADF	34.1	35.8	40.8
% NDF	46.5	47.1	54.6
% IVDMD	61.8	61.3	56.8

Average of 2 Trials
Samples were soaked in a water volume equal to 25 mm (1 in.) of precipitation
% Protein – calculated from % nitrogen multiplied by 6.25
% ADF – per cent acid detergent fiber
% NDF – per cent neutral detergent fiber
% IVDMD – per cent in vitro dry matter disappearance

Collins, M., 1991. Hay curing and water soaking: Effects on composition and digestion of alfalfa leaf and stem components. Crop Sci. 31: 219 - 223

RAIN DAMAGED SWATHS LEFT FOR AN EXTENDED PERIOD CAN SMOTHER THE FORAGE UNDER THE SWATH

RAIN DAMAGE ON HAY SWATHS CAN REDUCE QUALITY

Rain has more affect on digestibility than on protein. The drier the hay is when rained on, the higher the leaching losses will be. These losses can be as high as 15 per cent of total dry matter. The growth of molds and other micro-organisms is greater during wet weather, and these organisms utilize the most nutritious portions of the forage. Leaf losses are much larger for weathered forage since it is often raked to enhance drying.

To enhance drying, tedders, swath inverters and rakes are used. As the swath dries in the field, the exposed top dries much faster than the material in the bottom of the swath. The swath can be mechanically rolled or inverted to expose the bottom material to the sun and wind to speed up the drying process.

Tedders have rotating tines that fluff and spread the swath, which can speed up the drying process. Tedding can reduce drying time by up to two days. Tedding should be done at moisture levels above 40 per cent to reduce losses. Average tedding losses are about 3 per cent dry matter with a range of 2 to 8 per cent being typical losses (Table 46). The majority of this loss is from the loss of leaves, decreasing digestible dry matter by 1.2 per cent on average. As the crop dries to below 30 per cent moisture, dry matter losses in alfalfa can be as high as 10 per cent with 70 per cent of these losses being from the leaves.

Swath inversion provides a more gentle method of exposing the bottom of the swath to dry. These machines lift the swath, turn it and set it back down on the ground. Swath inverters are not as effective at speeding up the drying process since they do not disturb and fluff the swath as much as tedders or rakes. Less disturbance also results in low dry matter losses (1%).

EW HOLLAND 144

SWATH INVERTER

Several designs of rakes roll and turn the windrows to enhance drying, sweep the forage into a windrow or combine or merge windrows together for baling. Raking tends to be one of the most aggressive harvest operations. Raking can decrease drying time by 10 to 20 per cent. Losses of 5 to 10 per cent of total dry matter for one raking are common, with potential losses being as high as 20 per cent or higher. A reduction of 1.2 per cent in the digestible dry matter (Table 46) can be expected when dry matter losses of 5 per cent occur. This figure indicates that most of the dry matter lost is from leaves. Raking when the moisture content is above 40 per cent, and decreasing the number of rakings will reduce leaf loss.

Most grass and legume forages are removed from the field and stored as bales. Bales can be round or square and can be small, medium and large. The large square and round bales can weigh 400 to 800 kg (880 - 1,760 lb). Small square bales weighing 20 to 35 kg (44 - 77 lb) can be handled by hand, which makes them very versatile but very labor intensive. Small square bales make a good package for marketing low volumes of forage to acreage and horse owners. Livestock producers feeding larger amounts of forage prefer larger bales that are more easily handled by mechanization and are not as labor intensive.

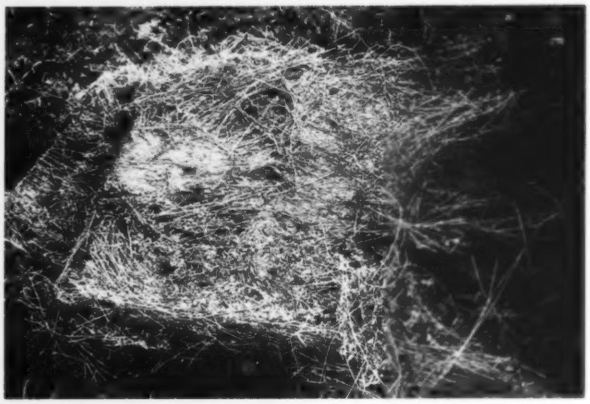
Baler dry matter losses are mostly leaf losses, which has a greater effect on the digestibility of the forage. Dry matter losses differ with the different baling systems. Large rectangular bales lose on average 3 per cent (Table 46) dry matter whereas the small square bales will lose 4 per cent dry matter divided between the pick-up and the chamber. Large round bales have the greatest dry matter loss, averaging 6 per cent under favourable conditions.

Baling losses can be as high as 10 to 15 per cent when the windrows are thin, the feed rate is low, the pick-ups improperly adjusted, the ground speed is slow and, especially, if the hay is overly dry. Losses in large round balers are particularly dependent on the feed rate into the baler. If the forming bale is rolled too much in the chamber, especially if the hay is overly dry, leaf breakage and loss will be high. This problem generally occurs when the windrows are small.

LOSSES FROM ROUND BALERS CAN BE HIGH IF THE HAY IS TOO DRY AND THE WINDROWS ARE TOO THIN

Leaf losses can be reduced without affecting the preservation qualities of the final product by operating at as high a moisture content as possible. With baling systems, this approach means operating at approximately 15 to 20 per cent moisture. The larger, denser bales need to be slightly drier and should be baled at 15 to 18 per cent moisture. Small square bales can safely be baled at 18 to 20 per cent moisture. Bales continue to lose moisture during storage although the larger and denser the bale, the slower they lose moisture and the drier the forage should be before baling. Bale moisture will generally stabilize at 10 to 15 per cent moisture and remain at this moisture level unless the bales are rained on or absorb moisture from the ground.

Hay baled at moisture levels that are too high will heat and increase dry matter and nutrient losses and develop molds. If the internal temperature of the bale gets too high, the heat will affect protein availability, and spontaneous combustion may occur. The precise moisture content at which deterioration begins depends on the size and density of the harvested "package," as well as on drying and storage conditions afterwards. Deterioration of quality may become a factor if hay is put up at too high a moisture content.



HAY BALED AT MOISTURE LEVELS THAT ARE TOO HIGH WILL HEAT AND CAUSE SPOILAGE

Proprionic acid is the most effective and most reliable preservative presently available to reduce heating and molding when hay is baled at moisture levels above the safe storage limit for the bale size and density. Hay may be baled at moisture levels of 25 to 30 per cent moisture if proprionic acid is applied at 1 to 2 per cent of fresh hay weight. Manufacturer's instructions should be followed for all proprionic acid application rates. Buffered mixtures of proprionic acid will reduce the corrosiveness of the acid on equipment.

Molds can cause a loss of dry matter when the microbial activity of these molds uses the plant carbohydrates as energy and gives off heat, which affects the quality of the hay. With dry haying systems, losses are mainly associated directly with the mold itself rather than with heating. However, if mold activity raises temperatures to 40° C or more, a complex reaction known as the "browning reaction" occurs. Once started, this self-sustaining chemical reaction results in a significant decrease in the digestibility of protein and carbohydrates in the forage. A dark brown or black colour indicates that less than 50 per cent of the protein may be digestible, and with severe heating, digestibility may be close to zero.

In the first month or so, respiration of micro-organisms in the hay (including covered dry hay) creates heat that breaks down dry matter and nutrients. If moisture levels are correct, the hay stabilizes, but if the hay has excessive moisture, then excessive heating and spoilage occur.

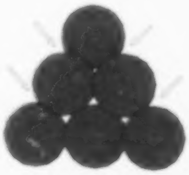
A large amount of forage is spoiled in Alberta as a result of leaving bales without protection from rain or snow. Dry matter losses from hay stored inside averages 5 per cent (Table 46) whereas hay stored outside can have losses from 6 to 30 per cent. Losses are higher if the bales are stored improperly outside. Typical dry matter losses in large round bales occur in the outer 15 to 25 cm (6 - 10 in.) where the bale is exposed to rain and snow as well as the ground. In the winter months, the spoilage is considerably less.

LOCALIZED MOLDS CAN OCCUR WHEN THERE IS UNEVEN DRYING OF SWATHS

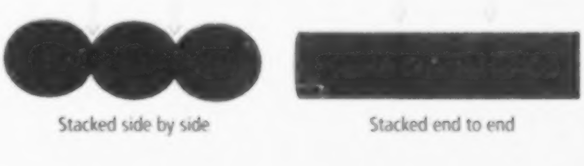
Covering large, well made stacks of compact bales will expose less surface and offer more resistance to moisture penetration. Large round bales that are not covered should be stored individually in rows with a gap between adjacent bales (Figure 78). However, with all baling systems, some form of protection from rainfall generally saves enough hay to justify its cost. The most reliable form of protection from rain is a hay storage shed, which works well for small square bales. Good tarps are available for covering stacks stored outside. Placing the stacks on gravel in well-drained locations reduces the forage-to-soil contact and spoilage.

Bale silage is another alternative to baling higher moisture forage. The fermentation process for bale silage is the same as for chopped silage. The quality loss when making bale silage is less than when making hay since there is less leaf loss, although if it is not properly baled or wrapped, the potential for quality losses during storage are very high.

FIGURE 78
Moisture allowed to build up in areas will create increased spoilage



Pyramid stack



Stacked side by side

Stacked end to end

WRAPPED BALE SILAGE

Benefits of storing the forage as bale silage as compared to hay or chopped silage:

- requires one quarter to half the drying time of hay
- weather is less of a concern
- lowers leaf loss by 5 to 10 per cent
- uses same equipment as dry hay
- requires less labor and energy than silage
- allows for movement of silage without spoilage

Disadvantages of bale silage in comparison to hay or chopped silage:

- fermentation is slower than chopped silage and respiration losses are greater
- there is less fermentation and the pH is higher than chopped silage
- storage life of feed is shorter
- bales with high moisture may freeze
- once plastic is removed, the bale silage must be used
- higher risk storage
- extra cost for bale wrapping equipment and plastic
- plastic disposal is a problem

Bale size and bale moisture content are important when making bale silage. When baling silage, the moisture content should be 40 to 60 per cent with 50 per cent the ideal moisture content. If the moisture is less than 40 per cent, the bale is not as firm and dense, and there will be less fermentation, increasing the potential for spoilage. If the moisture content is greater than 70 per cent, the bales are very heavy, and there is an increased risk of butyric acid formation, effluent seepage and the potential for frozen bales. The bales should be firm, dense and wrapped evenly to reduce trapped air.

When baling round bales for silage, reduce the swath density and slow down the ground speed of the baler. This method will generally make a denser bale, which will reduce the air pockets that cause molds. Medium-size square bales make good bale silage as they are generally denser than round bales, which will increase fermentation.

If the size of the bale for silage is the same as the size as the bale for hay, the silage bale will weigh considerably more and bale handling becomes an issue. If a 1.5 meter (5 ft.) bale weighs 450 kg (1,000 lbs) at 20 per cent moisture, the same diameter bale will weigh 590 kgs (1,300 lbs) at 40 per cent moisture and 770 kgs (1,700 lbs) at 55 per cent moisture. Specialized balers for bale silage have been developed with a cutting attachment that shortens the straw length and may increase fermentation. Some balers have a built-in bale wrapper.

REDUCE BALE SIZE FOR BALE SILAGE

Many times, producers want to make bale silage from swaths that have been rained on and are too wet for storage as hay. Rain leaches out nutrients, resulting in low water soluble carbohydrate levels, and the product ensiles very poorly, resulting in heating and molding.

Bales for silage should be wrapped the same day they are baled to prevent heating and spoilage. For wrapping bales use, 1 mil plastic film with 50 per cent stretch, resistance to UV light and good tear strength and adherence. A minimum of four wraps should be used, and six wraps is better. The bales may be wrapped individually or placed in a tube.

Very little hay is stored as loose hay due to the equipment, labor and time requirements for harvesting and feeding. Harvesting losses with loose hay stackers are extremely variable. Losses tend to be somewhat higher than with baling systems, averaging 10 per cent of total dry matter. An operator experienced at forming dense stacks with smooth and well rounded tops can keep losses comparable to other dry forage harvesting systems.

Silage Harvesting and Storage

Overall nutritive losses with silage systems tend to be less than for other methods of harvesting forage. Since making silage depends less on favourable weather, there is greater control of the quality of the final product. The main advantage is the decrease in losses between cutting and storage. Total leaf losses with silage are very low compared to dry harvesting systems.

Leaf losses with wilted silage (moisture content 50 - 70%) are about 5 to 7 per cent. Wilted silage results in improved fermentation and few storage and seepage losses, and it is the preferred method of making silage. Respiration losses in the field are about 3 per cent of dry matter per day, but total drying time is only one-fourth to one-third of that required for dry hay systems so that total respiration losses are much lower.

Dry matter losses during storage of wilted silage are about 5 to 6 per cent with oxygen limiting silos, 8 to 10 per cent with upright concrete silos and 10 to15 per cent with well made horizontal silos. Silage losses are very dependent on silage making and silage storing management.

Moisture contents above 70 per cent result in poor fermentation and excessive seepage. With moisture below 50 per cent, heat damage is a likely problem, although oxygen-limiting silos permit the ensiling of somewhat drier material. Silage temperatures over 40° C result in high dry matter losses and a decrease in the digestibility of proteins.

Forage should be chopped to an average actual length of 12 mm to assure adequate packing of the silage. Low moisture silage requires still shorter lengths to permit adequate packing. Silage must be packed well to prevent air penetration. With horizontal silos, continuous packing during filling is desirable. If filling is stopped for more than a day the silo should be covered. Immediately after filling is completed, silos should be sealed with a plastic cover that should be weighted down to eliminate air pockets to prevent excessive surface spoilage. For more silage information, refer to Alberta Agriculture's *Silage Manual* (Agdex 120/52-2).

SILAGE CUTTER

SILAGE BUNKERS

Summary

While the highest hay quality is desirable for production rations, such as for milk production and body growth, lower quality roughage is useful for maintenance rations. However, when the feed is of higher quality than required, it can be mixed with lower quality feed such as straw, which is usually available. It is generally more economical to utilize lower quality feeds through mixing of feeds (e.g. mixing straw and hay). Therefore, it is advantageous to harvest a maximum amount of protein and digestible nutrients by early cutting of forages.

Every forage harvesting system has its advantages and its disadvantages. Dry hay systems have the potential for high dry matter losses in the field, whereas high moisture systems such as silage or bale silage have the potential for high storage losses. While some systems are more vulnerable to losses than others, all methods can successfully harvest and store forages if the process is understood. The final choice in storage systems depends on the individual farming operation, management and economic factors.

PASTURE AND HAY REJUVENATION

Pasture and Hay Rejuvenation

As stands of pasture and hay lands become older, undesirable species and weeds begin to dominate the forage stand, causing a decline in productivity and quality. To improve productivity, the forage crop can be rejuvenated with expensive tillage operations that can include plowing, disking, cultivation and re-seeding.

Less aggressive rejuvenation can also be done by improving grazing management, seeding into the established stand, applying herbicides and increasing fertility. Many times, rejuvenating hay fields or pastures can be done without removing the existing stand.

POOR CONDITION OF PASTURE THAT REQUIRES REJUVENATION

Breaking up the existing stand using tillage and re-seeding is not only costly, but the re-establishment disrupts a continuous supply of pasture and hay production. Re-establishment increases the risk of soil erosion, surface water runoff and a loss of organic matter.

The disruption in forage production requires producers to temporarily reduce livestock numbers or source another supply of pasture or stored feeds. The success rate of any rejuvenation of perennial forages is very dependent on weather conditions and good management practices.

Assessing the Forage Stand

When assessing pastures and hay land, it is important to realize the difference between the symptom and the actual problem. A symptom is an outward sign that something is wrong or out of balance. For example, brush encroachment can be a symptom of a problem such as poor grazing management. The invasion of undesirable species can be a symptom of poor grazing management or low soil fertility.

When planning a rejuvenation project, compare the present production with the expected increased forage yield and quality after rejuvenation. The cost of breaking up the stand and re-establishing the improved species, as well as the length of time the stand is out of production, must also be considered.

An assessment of the forage stand should be used to evaluate the need for and method of rejuvenation. The assessment should include the following:

- species desirability
- species diversity
- plant density
- plant vigour
- per cent legume
- severity of use
- uniformity of use
- soil erosion
- plant residue
- litter
- woody canopy
- perennial weeds

PASTURE ASSESSMENTS ARE DONE TO DETERMINE IF AND WHAT TYPES OF REJUVENATION PRACTICES ARE REQUIRED

Existing plant counts of 65 to 110 plants/m^2 (6 -10 plants/ft.^{2}) of bunch type grasses and legumes should be sufficient numbers for reasonable dry matter production for pasture or hay. A more accurate stand assessment of a pure stand of alfalfa is having stem counts of 485 to 590 stems/m^2 (45 - 55 stems/ft.^{2}), which will provide maximum yield. Creeping rooted grasses spread quickly to fill in stand gaps under favourable conditions, making stand density at the time of assessment less critical.

Good to excellent forage stands require 75 per cent or more production from desirable species. Less than 50 per cent of the total dry matter production coming from the desirable species indicates poor pasture and hay production.

Soil samples should be taken to determine soil nutrients. Soil sample separately the areas of the field showing symptoms of poor growth or the invasion of undesirable species to identify potential nutrient deficiencies.

Tissue sampling is not as commonly used as soil sampling, but results can help to identify specific nutrient deficiency problems in the field. If planning to tissue sample, contact the laboratory that will be doing the analysis to ensure proper sampling procedures are followed.

It is important in any rejuvenation project to determine and correct the problem or problems associated with the need for rejuvenation. An assessment of the problem will assist in determining the correct rejuvenation method to be used. Properly correcting the underlying problem will ensure a reduction of the need for future rejuvenation projects in this field.

Methods of Rejuvenation

When using methods of rejuvenation other than conventional breaking and re-seeding of the existing stand, it is important to remember that the establishment of new seedlings will be slower than with conventional methods of seeding. The success of forage rejuvenation is very dependent on weather conditions, especially precipitation levels during establishment.

Controlled and Managed Grazing

Continuous grazing allows livestock to continuously select the most desirable species and unless an area is overgrazed, the method never forces animals to graze less palatable species or perennial weeds and woody plants such as willow or aspen. Continuous close defoliation of pasture plants will favour species with a high proportion of leaves below grazing height, such as bluegrass.

Overgrazing occurs when plants are continually grazed without rest periods to allow plants to recover. Plants become stressed if regrowth is grazed before the plants have time to replace carbohydrates in the roots. Subdividing fields into smaller paddocks will allow for a higher stocking density and will result in shorter grazing periods and longer resting periods.

Shorter grazing periods with higher stocking densities will also allow for more equal utilization of desirable and undesirable plants and better distribution of manure from the grazing livestock (see Pasture section).

CONTROLLED GRAZING ENSURES PASTURES REMAIN PRODUCTIVE

A decrease in pasture production with an increase in undesirable plants is usually an indication of poor grazing management. Frequent cutting or grazing reduces the amount of leaf area of forage plants and will reduce photosynthesis, resulting in less dry matter production.

Longer rest periods allow plants to build higher levels of root carbohydrates and increase root development, which improves production, winter hardiness and drought tolerance. The most critical time to use rest as a method of rejuvenation is during the most active growing time of the year, from first growth to early July. During this time, plants are recovering from the stress of overwintering. Pastures in the drier areas and pastures in really poor condition may need a full year "rest period" to help rejuvenate a pasture if it has been severely overgrazed.

Using controlled grazing as a method of rejuvenation may require a reduced carrying capacity for a year or two. Treed areas and access to water (e.g. dugouts) should be fenced off, and water should be provided to the individual paddocks, which will reduce the loitering areas and help maintain the manure on the pasture.

A rotational grazing system is much easier on taller growing plants such as the bromegrasses and alfalfa, which respond to shorter grazing periods and longer rest periods. Using longer rest periods as a method of rejuvenation, especially during the early growing period, will result in plants heading out and producing seed. The pasture quality is lower, but the seed production from the forages will help to re-seed the pasture.

This approach works best on non-creeping or bunch grasses such as timothy, orchardgrass and most legumes. The quality of the pasture is reduced when the forages are allowed to mature, which may be beneficial to the rejuvenation. There will be a reduction in the livestock dry matter intake, which will increase the amount of residue or litter left on the pasture.

If a managed grazing system is used, the longer than normal rest periods would not be required once the pasture becomes productive again. If controlled grazing is used to control undesirable woody species, heavy grazing of these species should take place during July.

FENCING OFF WATERING AREAS HELPS KEEP MANURE ON THE PASTURES

Fertilizer

Fertilizer as a method of rejuvenation is used when soils have a nutrient deficiency. Many pasture and hay stands are considered to be "sod bound" when production is low even though plant numbers are high. This condition is most common with creeping rooted or rhizomatous species such as smooth bromegrass, Kentucky bluegrass, etc. Fertilizing the forage crop will stimulate new top growth and new root and rhizome growth.

Perennial forage crops respond to fertilizer applications, especially nitrogen, when soil nutrient levels are low. The response to fertilizer is very dependent on species, soil moisture conditions and nutrient levels in the soil. Nitrogen is used to break down organic matter, and if the thatch layer is too thick, it may take higher than recommended rates to stimulate new growth. As this organic matter in the thatch breaks down, nitrogen is then released into the soil for the plant to utilize.

Fertilizer requirements for forages in well managed pastures are not as great as for hay and silage production. In hay and silage crops, nutrients are removed from the stand whereas in pastures, the nutrients can be recycled. Soil nutrients from pastures are exported as meat or milk.

A cow-calf pair will remove approximately 5 kg (11 lb) of nitrogen, 2 kg (4.5 lb) of phosphorus and 1 kg (2 lb) of potassium over the grazing season. With high intensity, short duration grazing, livestock manure and urine are distributed on the pasture more evenly, resulting in improved nutrient cycling, compared to systems with low intensity and long grazing periods (see Fertility section).

FERTILIZER APPLICATIONS CAN BE USED TO REJUVENATE PASTURES IF SOILS ARE DEFICIENT IN NUTRIENTS

Mechanical Disturbance

Heavy intensive grazing can increase soil densities and penetration resistance, particularly early in the grazing season or at times when soil conditions are extremely wet. This situation is more common when there is very little or no humus layer and the plants have a very shallow root system. The soil becomes capped or hard to break open, resulting in reduced water infiltration and greater water runoff. These conditions contribute to soil compaction and poor soil structure, resulting in poor pasture production. Soils with these conditions limit root development resulting in reduced yield and growth of desirable pasture species.

To solve the problem of "sod bound" and compacted soil, equipment to mechanically aerate pastures is sometimes used. Any tillage equipment that will moderately disturb the top 5 inches of soil in a pasture can be considered. Tillage operations will enhance the decomposition of plant residue and roots, releasing nutrients, especially nitrogen, to the plants.

Work in Saskatchewan on older established pastures compared the use of fluted coulters and 2 cm (3/4 in.) wide knives with and without fertilizer application. The treatments were conducted early in the spring, and yield results were taken for three years after the treatments. There was no yield response from using knives or fluted coulters without fertilizer.

Research in central Alberta indicates there is no consistent benefit to mechanically aerating pasture or hay land. Aeration in early spring, fall or a combination of early spring and fall at several Gray Wooded sites in central Alberta had no beneficial effects on dry matter yields on pasture or hay production (Table 48).

TABLE 48
Influence of mechanical aeration on dry matter yields (kg/ha) on pastureland in central Alberta

	Leslieville	Stauffer	Millet
Check	7,014	5,275	2,639
Fall	6,874	5,425	2,579
Spring	6,719	5,413	2,367
Fall + Spring	6,934	5,191	2,259

Average of 2 years – 1991 and 1992

S.S. Malhi – Lacombe Research Centre, Agriculture and Agri-Food Canada

Aerating may be beneficial when overseeding pastures as it improves seed-to-soil contact or when used in conjunction with fertilizer and/or a manure application. Aerating equipment can be used to assist with the incorporation of seed, fertilizer and manure.

If mechanical disturbance is used as a method of rejuvenation, it should be done as early in the spring as possible. This timing allows the stand to recover and encourages micro-organisms to decompose organic material, releasing nitrogen for plant utilization. Good soil moisture is required for effective disturbance.

Herbicides

A careful assessment should be completed before any major use of a herbicide for rejuvenation of a pasture. The invasion of weedy plants into a pasture is almost always a symptom of poor grazing management. Herbicides can be used to selectively reduce and suppress undesirable plant species, but the benefits will not be long lasting unless a change in grazing or soil fertility occurs. Most herbicides that effectively control perennial broadleaf weeds and herbaceous plants will also suppress or kill legumes. Fertilizing to encourage the growth of forages will help in controlling or suppressing weeds. The combination of herbicides and fertility has been shown to provide good control of a number of problem weeds in pastures.

Recommended herbicides can be applied with a regular field sprayer, but on rough terrain, aerial application may be required. Weed wipers (wick applicators) can be used on weeds that grow taller than the productive pasture species. Pastures can be grazed to remove the taller grasses and legumes, which will allow improved access to the weeds for wiping with herbicides. Herbicide concentrations usually need to be increased when using wiper applicators. For example, the use of a 30 to 50 per cent concentration of a glyphosate product has provided effective control on some species of perennial weeds such as Canada thistle when applied with a weed wiper in the fall. Always follow manufacturer recommendations when using herbicides.

Herbicides used for brush control should be applied after the leaves are fully developed. Application should occur before the leaves develop a thicker cuticle, which occurs later in the growing season. The best results have been obtained with applications in July.

BRUSH ENCROACHMENT ON TAME PASTURE LAND

Mowing and bark scrapers can also be used to control woody species such as young aspen and willow. Removing bark off the young trees will kill the growth above the ground. Bark scrapers can be made from old cat rails or grader blades. Mechanical controls should be carried out when the roots of the perennial weeds or the woody plants are at their lowest levels of energy storage, which is usually during July.

BARK SCRAPERS CAN EFFECTIVELY REDUCE WOODY PLANTS IN PASTURES

Overseeding with Legume and Grass Seed

Successful establishment of legumes or grasses into existing stands is very dependant on favourable weather conditions, especially good moisture, and is generally only applicable to the more moist regions of Alberta. Alsike clover, white clover, red clover, timothy and orchard grass have been the most common species to establish by overseeding.

Seeding rates generally used are one half to three quarters of those required for a full legume or grass stand. The hoof action from a high stocking rate when grazed, the use of flexible chain link harrows, a light shallow cultivation or an aeration treatment all incorporate some of the broadcast seed for improved germination and emergence.

CLOVER ESTABLISHMENT IN PASTURE FOLLOWING BROADCASTING THE PREVIOUS YEAR

A mixture of legume seed with loose salt at a rate of approximately 5 to 10 per cent by weight can be fed to cows to excrete in their feces to spread the seed. This practice is very dependent on an even distribution of animals and manure across the pasture. Only legumes should be used as they have a hard seed coat that will not break down in the rumen when ingested. The success of this method of overseeding is highly variable.

When trying to seed alfalfa into existing stands with old alfalfa plants, it is important to consider the possible effects of autotoxicity. Autotoxicity occurs when established alfalfa plants release toxins into the soil that hinder establishment. The toxins have some effect on germination but most seriously affect early root growth and development.

Thickening poor alfalfa stands by re-seeding into the existing stand should be done when the stand is still very young. Toxins will remain in clay soils longer than sandy soils and will break down more quickly under warm, moist soil conditions. Alfalfa should be rotated out of the crop rotation before re-seeding back to alfalfa. There should be at least one growing season between the time all alfalfa plants have died and alfalfa is re-seeded.

Winter Pasture Feeding

The practice of winter feeding on perennial pastures has been a successful method of rejuvenating older unproductive pastures. Cattle utilize approximately 10 to 25 per cent of the nutrients consumed for milk and livestock production. The remaining nutrients are passed through the livestock as feces and urine and are available for plants to utilize. Bale grazing or winter feeding livestock on unproductive pastures allows the nutrients from wasted feed and manure to be utilized by the grasses and legumes in the following growing season.

BALE GRAZING CAN BE AN EFFECTIVE METHOD OF REJUVENATING FORAGE STANDS

MANURE DISTRIBUTION ON PASTURE AFTER WINTER BALE GRAZING

Nutrient concentrations are poorly distributed in whole bale grazing areas compared to winter feeding processed or unrolled bales. Whole bale grazing tends to concentrate the wasted feed and manure in the area around the bale, whereas when feeding processed feed or unrolled bales, the wasted feed and manure are spread over a larger area.

Direct Seeding Forages

Perennial forages can be direct seeded in two ways: either into a hay or pasture stand without herbicide treatment to the existing stand or into a hay or pasture stand shortly after the existing stand has been sprayed with a herbicide to remove the stand or after the annual crop has been removed. The success of direct seeding forages into existing forage stands has been inconsistent.

SEEDING INTO AN UNTREATED FORAGE STAND OR SOD

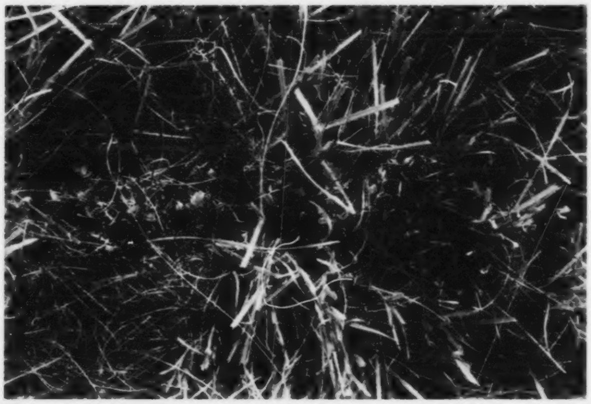
The success of this method of rejuvenation depends heavily on several factors:

- the existing species composition
- the amount of bare ground between plants
- soil moisture conditions
- soil fertility
- the grazing or cutting management following seeding

If the existing stand is composed of species with bunch type growth rather than grasses with creeping roots, a higher success rate can be expected. For example, seeding a new species into a stand of alfalfa or orchard grass may be more successful than seeding into an old stand of smooth bromegrass or creeping red fescue.

It is important that the existing top growth be removed by grazing or cutting before seeding to allow the new forage to establish. Grazing animals generally prefer the new seedlings making it difficult to graze without favouring the newly establishing plants. Some successful seedings have been established by spraying out strips of the existing vegetation and seeding into the strips. Availability of equipment for strip spraying limits the use of this practice.

SEEDING FORAGES INTO AN EXISTING PASTURE STAND



ALFALFA DIRECT SEEDED INTO MEADOW BROMEGRASS

REMOVING THE EXISTING FORAGE STAND

Using conventional tillage methods to remove perennial forages from the rotation is costly, increases the risk of soil erosion, increases losses of soil moisture and generally is not as effective as spraying out the stand with non-selective herbicides. Spraying the existing stand removes the competition and allows for direct seeding of forages or an annual crop into the stand without tillage.

SPRAYING OUT A FORAGE STAND

A higher level of control is achieved by spraying a perennial forage stand in late summer or early fall, rather than in spring (Table 49). There is greater downward translocation in perennial plants later in the growing season, allowing greater movement of herbicide into the root system. Fall treatment also allows for a greater build-up of soil moisture levels for the crop to be seeded the following spring.

In the case of legumes, a fall spraying will allow the crop to fix nitrogen for the full growing season for use by the following crop. Fall applications allow more time for the sod to break down, reducing the phytotoxic effects of decaying sod, and provide a better seed bed for spring seeding.

Glyphosate products provide more effective control when the forage crop is actively growing. Grasses should have at least three to four leaves per shoot or tiller, and legumes should be in the bud or blooming stage. For effective control of legumes in the pre-bud or earlier growth stages, consider mixing products such as 2,4-D or dicamba with glyphosate. Always follow label recommendations, and ensure products are registered for tank mixing.

A light frost of -2 to -3° C just before or after an application will not reduce the effectiveness of the glyphosate, provided daytime temperatures return to approximately 15° C. If a heavy frost (-4° C or more) occurs, wait three days until the plants have recovered and are actively growing and then apply the glyphosate.

Grass species with fine leaves and a very extensive root system, such as creeping red fescue or Kentucky bluegrass, are very difficult to control with one treatment of a glyphosate product (Table 50). Plants with a greater leaf area absorb herbicides better than plants with fine leaves, which also reduces herbicide effectiveness. The extensive root system of these plants allows regrowth to occur a few months after the herbicide treatment. Regrowth of the forage stand, especially grasses, competes with the annual or perennial crop planted after the herbicide treatment. Higher than average rates of glyphosate products or an additional treatment may be required to effectively control grasses with fine leaves or extensive root systems.

A pre-harvest treatment with a registered glyphosate product is one of the most commonly used methods to remove a perennial forage crop from the rotation. Three to four days before the crop is to be grazed or harvested, the pasture or hay field should be sprayed with a glyphosate product to allow the herbicide time to translocate or move into the root system. Quality of the crop does not appear to be affected provided the crop is grazed or cut within seven days after treatment.

Treatment of a forage crop prior to the first harvest allows the seeding of an annual crop for silage, greenfeed or swath grazing after the forage has been harvested and removed from the field. It also provides the option of seeding a winter cereal for grain or fall and spring pasture production. Seeding the annual or perennial crop shortly after the application of a glyphosate product increases the risk of disease organisms from the breakdown of sod affecting the establishment or yield of the newly seeded crop, but it has not been a major problem.

Spring or winter cereals, oilseed and pulse crops have all been grown successfully by direct seeding into a treated stand. The annual crop to be seeded will depend on the type of forage being sprayed out and the in-crop herbicide options for volunteer forage control. Oats is a good choice for direct seeding into sprayed-out forage stands.

TABLE 49
Control of alfalfa with herbicides applied in the fall versus spring

Treatment	Rate L/Acre	% Control Fall Application	% Control Spring Application
Glyphosate (360 g/l)	1	92	69
Glyphosate (360 g/l)	1.5	100	73
Glyphosate (360 g/l)	2	100	88
Glyphosate(360 g/l) + 2, 4-D Ester (450 g/l)	1 + 0.5	100	86
Glyphosate (360 g/l) + 2, 4-D Ester (450 g/l)	1.5 + 0.5	100	94

Smokey Applied Research and Demonstration Association. Falher. 1997

TABLE 50
Long-term control of grasses with a fall application of glyphosate in 1993

	Visual Rating (%)		
Grass Species	**June 1994**	**September 1994**	**July 1995**
Meadow Fescue	78	96	74
Orchardgrass	86	26	14
Timothy	90	96	74
Crested Wheatgrass	91	91	68
Meadow Bromegrass	90	65	30
Smooth Bromegrass	68	40	51
Creeping Red Fescue	66	34	0
Tall Fescue	96	94	86
Meadow Foxtail	45	65	30
Intermediate Wheatgrass	95	96	85

Application of 1 L/acre of glyphosate (360 g/l) in September 1993
Visual observations and ratings taken June 1994, September 1994 and July 1995

Cole, D. Alberta Agriculture and Rural Development. 1993

Annual cropping for a year or two before re-seeding a perennial crop will generally result in better establishment of a hay or pasture crop. This situation is particularly true if the previous forage crop was a sod bound crop of fine bladed grasses.

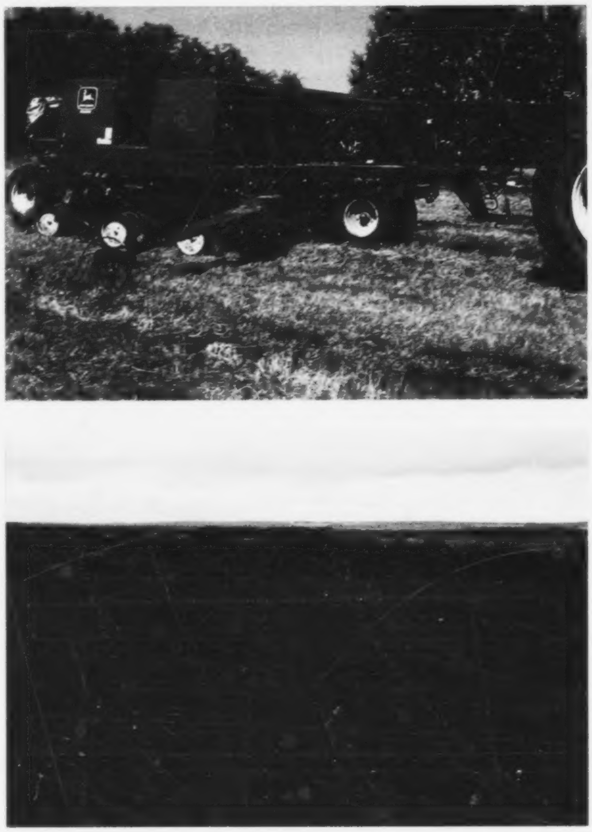
Direct seeding drills with disk-type openers provide the best results when seeding into a treated or untreated sod. Using drills with narrow knives will result in rough fields, especially if there is heavy sod.

SUMMARY

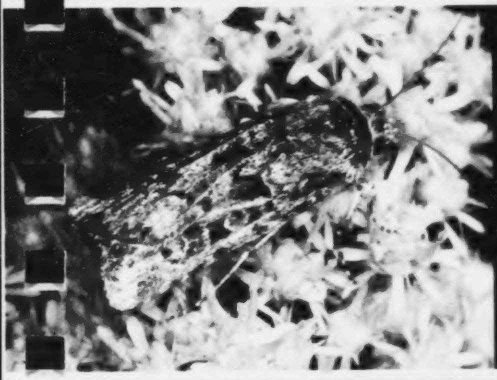
Although the traditional breaking and re-seeding is often the most commonly used method to improve hay and pasture production, the costs and risks associated with this method limits its use in many cases.

Some rejuvenation methods require non-traditional equipment and the application of non-standard methods and techniques. Equipment for mechanical disturbances and sod seeding may not be commonly available, and producers may need to arrange for custom operators. Many of the rejuvenation methods discussed in this chapter reduce the cost and risk associated with improving forage stands.

It is important to assess the present condition of the forage stand to help determine what method of rejuvenation is required. It is also important to determine the cause of the problem that created the need to rejuvenate to ensure the problem is corrected to avoid future rejuvenation projects.



DIRECT SEEDING ANNUALS INTO SPRAYED OUT FORAGE STANDS



FORAGE PEST INSECTS

Forage Pest Insects

In North America, nearly 1,000 species of insects have been found in alfalfa fields and many additional species are found in other forage crops. The vast majority of these species have little or no effect on forage production. However, some are important as pests and others play significant roles as pollinators, predators or parasitoids. Others play an indirect role by assisting in the decomposition and nutrient recycling of crop debris.

Forages grown for pasture, hay and silage are essential for Alberta's large livestock industry. In addition, they are the basis of a substantial processed forage export business and a forage seed industry. Insect pests can be a serious and recurring problem in the management of forage crops. This section describes the more common pest and beneficial insects encountered in Alberta forage crops.

Integrated pest management is the timely use of suitable cultural, biological or chemical control strategies to limit pest populations to below thresholds of economic injury while minimizing harmful effects to the environment. This approach has proven more useful for managing pests in perennial crops such as forages than in annual crops.

Effective pest management depends on the correct identification of the species causing the damage, determination of the actual level of the pest population, using an appropriate sampling method such as sweeping with an insect sweep-net and comparing this level to an established economic threshold, if known.

Sweep-net sampling (38 cm diameter net) is a common method employed to determine pest populations and to gather samples for identification. Typically, one sweep is equal to a 180 degree arc swept while walking forward through the crop canopy.

SWEEP-NET SAMPLING

If chemical control is needed, correct application with respect to choice of insecticide, timing and rate of application and type of equipment used is necessary. Cultural practices such as weed control, early spring and post-harvest harrowing or removal and burning of straw and chaff can help to control insect pest populations. Seeding hay fields next to established seed fields, or new stands near old ones should be avoided.

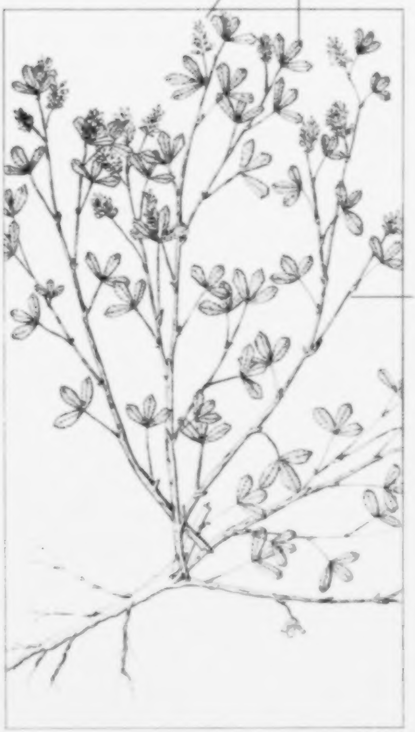
Natural enemies play an important and often unrecognized role in controlling pest species. Predatory and parasitic insects, disease organisms and inclement weather can destroy much of a pest population and often keep such populations below the economic threshold. Some of the most common and effective insect control agents found in forage fields are listed in the section Natural Enemies of Pest Insects.

Recommendations for insecticides are not given in this manual because they change frequently. Each year, Alberta Agriculture and Rural Development publishes a book with the latest chemical control recommendations, *Crop Protection*, Agdex 606-1. All directions and precautions listed on the insecticide label should be followed carefully. In most cases, a preharvest time interval is required between the last insecticide application and harvest. The length of the preharvest interval varies with the crop, crop stage, pesticide used and amount of pesticide applied.

Most insecticides have a broad spectrum of activity, and care should be taken to minimize the effect on honeybees, other pollinators and natural enemies. When it is necessary to treat a crop in bloom, insecticides that pose the least risk to bees must be used. Direct spraying of bees can be largely avoided by applying the insecticide in the evening after the bees have left the field or before they return in the morning, usually after 7 p.m. or before 7 a.m. Insecticide drift into bee yards or adjacent crops in bloom must be avoided. Beekeepers should be notified at least 48 hours before spraying, so they can take measures to protect their bees.

Damage to a forage crop from pest insects is more likely when the crop is stressed by conditions such as drought or nutrient deficiencies. Often, the best defense against insect damage is a healthy, rapidly growing crop. The parts of plants typically affected by the insect pests that most commonly occur on forages grown in Alberta are shown in the following drawings. Detailed biological and control information for each pest species follows.

Alfalfa

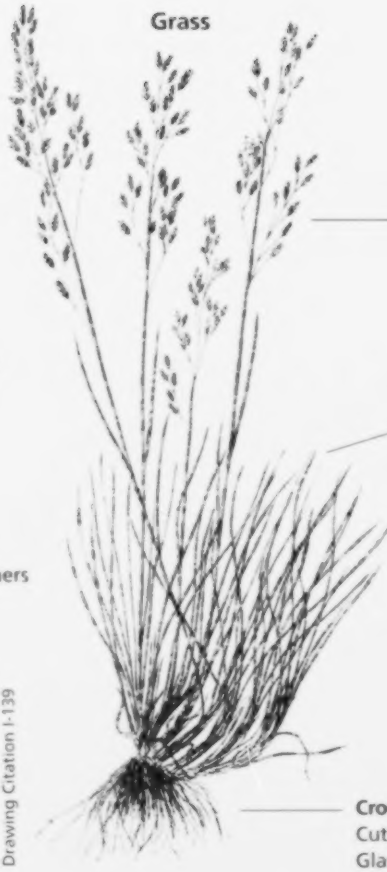


Buds, flowers, pods, seeds
Alfalfa Plant Bugs
Lygus Bugs
Seed Chalcids

Shoots, leaves, stems
Pea Aphids
Legume Aphids
Alfalfa Weevils
Grasshoppers
Alfalfa Curculios
Alfalfa Loopers
Alfalfa Caterpillars
Alfalfa Biotch Leafminers
Leafhoppers
Mites
Thrips
Blister Beetles

Drawing Citation A-486

Grass



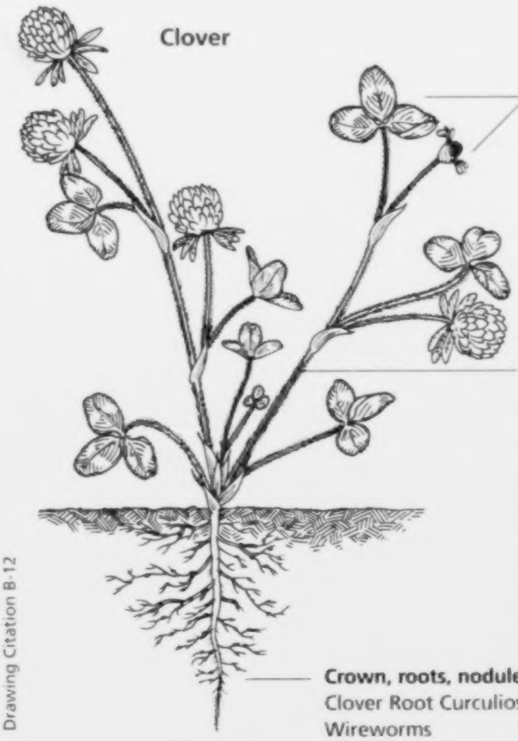
Boots, panicles, seeds
Grass Plant Bugs
Brome Grass Seed Midge

Leaves, stems
Cutworms
Grasshoppers
European Skipper
Leafhoppers
Mites
Thrips

Crown, roots
Cutworms
Glassy Cutworms
Sod Webworms
Wireworms
White Grubs
European Chaffer

Drawing Citation I-139

Clover



Buds, flowers, pods, seeds
Alfalfa Plant Bugs
Lygus Bugs
Seed Chalcids
Legume-feeding Casebearers
Clover Seed Weevils

Shoots, leaves, stems
Pea Aphids
Legume Aphids
Grasshoppers
Sweet Clover Weevils
Clover Leaf Weevils
Lesser Clover Leaf Weevils
Leafhoppers
Mites
Thrips
Blister Beetles

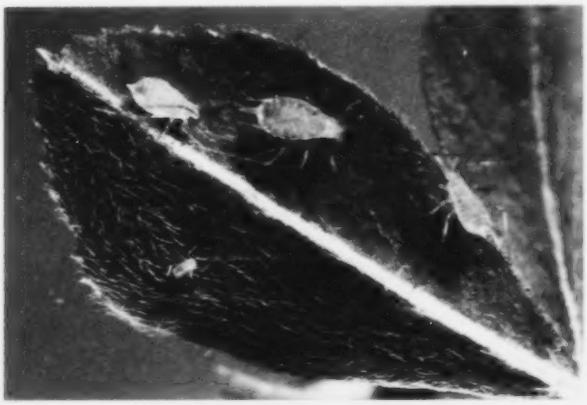
Crown, roots, nodules
Clover Root Curculios
Wireworms

Drawing Citation B-12

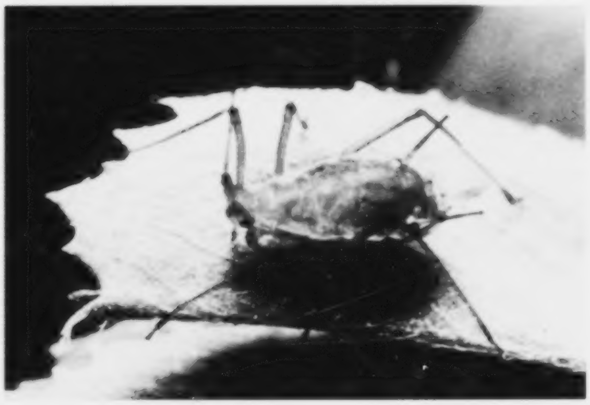
ARTHROPOD PESTS AND AFFECTED PLANT STRUCTURES COMMONLY OCCURRING ON ALFALFA, CLOVER OR GRASS PLANTS

Pea Aphid

The pea aphid, *Acyrthosiphon pisum* (Harris), can severely damage alfalfa. This insect, found wherever peas and forage legumes are grown, feeds on alfalfa, sweetclover, field peas, lentils, trefoil and some species of vetch and clover.



PEA APHID ADULTS (2 MM) AND ONE APHID NYMPH ON ALFALFA LEAF



PEA APHID ADULT (2 MM) ON ALFALFA LEAF
NOTE CORNICLES ("TAILPIPES") ON SIDES OF ABDOMEN

DAMAGE

Pea aphids mainly infest the tender growing tips of the host plant. Both adults and nymphs have piercing-sucking mouthparts and suck the juice from the infested plant part. In alfalfa, a heavily infested area in a field may appear pale or brownish from a distance. The plants may be stunted and wilted with the upper leaves light green and the lower ones yellow, senescent or absent. Bare ground beneath the plants is often covered with whitish molted skins of the aphids.

High pea aphid populations can reduce flowering and seed production; they can also transmit verticillium wilt and reduce cold hardiness. Persistent infestations suppress alfalfa growth and can result in weed problems.

DESCRIPTION AND LIFE HISTORY

The adult pea aphid is pear-shaped, soft bodied, with long legs and antennae and a pair of slender cornicles (tailpipes) near the end of the abdomen. They are slow moving, about 3 mm long and 1.5 mm wide and range from light to dark green. The nymphs are smaller but otherwise similar.

The pea aphid, like many other aphids, has a complicated life cycle. In Alberta, pea aphids overwinter as eggs on leaves and stems of perennial legumes such as alfalfa and clover. In spring, when plant growth resumes, the eggs hatch, and all the young develop into wingless female adults that reproduce without mating, giving birth to active nymphs, which also all become wingless females. A summer-form female can produce 50 to 150 young during her life. Pea aphids develop from birth to maturity in one to three weeks depending on the weather. Warm, dry conditions are conducive to rapid development

When the food quality of the host plants starts to decline, some of the nymphs become winged female adults that can disperse to other fields of alfalfa or annual legumes, such as peas, where they produce wingless females that give rise to further generations of females. Whenever an alfalfa crop is cut, any winged aphids present leave to search for new host plants. Towards fall, a wingless sexual generation consisting of both females and males is produced that mate, and the females lay the overwintering eggs. The eggs are yellow when first laid but soon turn green and then shiny black.

Although pea aphids can overwinter successfully in Alberta, they also occur as migrants. Influxes of migrants occur when southerly winds reach Alberta after passing over source areas further south. If migration occurs early in the season, large populations can build up rapidly, and control measures may occasionally be necessary in late May or early June. However, populations do not usually peak until late July or early August.

CONTROL

Predators, parasitoids, pathogens and unsuitable weather usually keep pea aphid populations below the economic threshold. Common predators include the adults and immatures of damsel and pirate bugs, ladybird beetles and lacewings and the larvae of hover flies. Some of these, especially ladybird beetles, frequently become abundant in early August, and high numbers may coincide with spectacular crashes in the aphid population.

Several species of tiny wasps are common parasitoids of aphids. They lay their eggs into the aphids, and the resulting larvae feed internally until the tissues of the aphid are entirely consumed. The parasite then pupates within the remaining shell of the aphid, forming a brownish, globular "mummy." A fungus disease that is favoured by warm, moist weather sometimes devastates aphid populations.

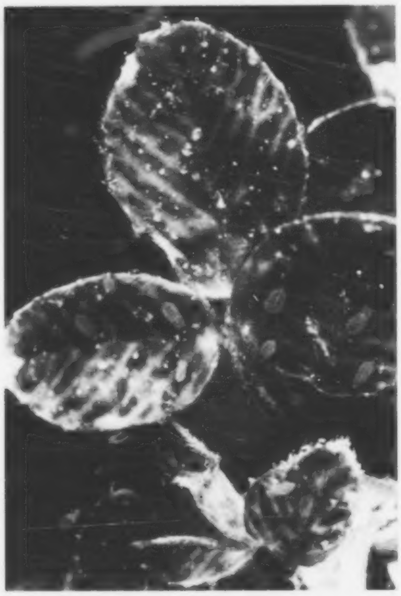
Conditions favourable for rapid crop growth greatly reduce the likelihood of aphid damage, whereas crops under drought stress are much more susceptible. Infestations will be retarded by cold, windy weather, and heavy rain can dislodge and drown many aphids.

Some varieties of alfalfa appear to be less susceptible to aphid infestation or damage than others. Cultivars of alfalfa with reduced susceptibility to pea aphids have been developed in the United States. However, most of these cultivars are not suitable to Canadian growing conditions, and their poorer agronomic performance usually offsets any advantage they might have in terms of aphid resistance.

Alfalfa fields should be monitored regularly for pea aphids, especially those fields under moisture stress or showing discolouration. Early cutting of hay fields will help keep aphids under control. If aphid numbers decline over several sampling dates, or if predator or parasite numbers are increasing markedly, control measures may not be necessary. Control is seldom justified in seed fields once pods begin to mature. Unnecessary insecticide use should be avoided because the aphids can re-infest rapidly, whereas populations of predators and parasitoids re-colonize much more slowly.

Other Legume Aphids

Several other species of aphids can damage legume crops in western North America. The spotted alfalfa aphid, *Therioaphis maculata* (Buckton), was first found in Alberta in 1979. Occurrences of this aphid have gradually increased since then, but there have been few reports of damage. Three other species, the yellow clover aphid, *Therioaphis trifolii* (Monell), the sweetclover aphid, *Therioaphis riehmi* (Börner) and the clover aphid, *Nearctaphis bakeri* (Cowen) now occur in Alberta but have so far not reached damaging levels. They rarely damage alfalfa. The clover aphid (*N. bakeri*) has occasionally damaged red and alsike clovers grown for seed in the lower Fraser Valley of British Columbia. The blue alfalfa aphid, *Acyrthosiphon kondoi* Shinji, was first detected in North America in California in 1974. While it is sometimes a severe problem in some Great Plains states, it has not yet been reported to occur in Canada.



SPOTTED ALFALFA APHIDS
NOTE APHID HONEYDEW AND VEINAL CHLOROSIS

DAMAGE

All aphids injure plants by sucking plant sap in the same manner as the pea aphid. However, some aphids such as the spotted and blue alfalfa aphids also inject a toxin into the plant as they feed. Initial damage by the spotted alfalfa aphid manifests as veinal chlorosis characterized by white veins on newly emerging leaves. Advanced aphid damage is characterized by yellowing of interveinal spaces then senescence of affected leaves. Infestation by either the spotted or blue alfalfa aphid causes stunting and yellowing of the entire plant, yield reductions and plant death when infestations are severe.

The production of honeydew by aphids can result in sticky plants at low infestation levels, but high infestations can be accompanied by the growth of a black fungus that grows on the honeydew and reduces forage value because it renders feed less palatable to livestock.

The spotted alfalfa aphid prefers to feed on the underside of the leaves on the lower part of the plant, and the damage progresses from the bottom of the plant to the top. Damaged plants can take weeks to recover, and severely infested plants can die. The blue alfalfa aphid feeds initially near the plant terminals and, if left unchecked, can destroy up to 50 per cent of an alfalfa hay crop. Sweetclover aphids occur as small colonies on the undersides of leaves. Heavy infestations cause defoliation and can result in severe damage to first-year alfalfa stands.

DESCRIPTION AND LIFE HISTORY

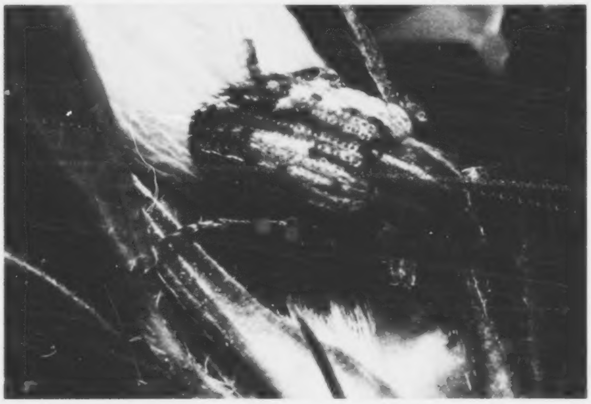
The three *Therioaphis* species are yellowish brown with varying patterns of dark spots in their backs. The clover aphid is light green or pinkish green while the blue alfalfa aphid is similar in appearance to the pea aphid but is smaller and more blue-green. Like the pea aphid, these species build up high populations rapidly under favourable conditions by giving birth to live young. They also produce winged forms that disperse when the condition of the host plant becomes unsuitable.

CONTROL

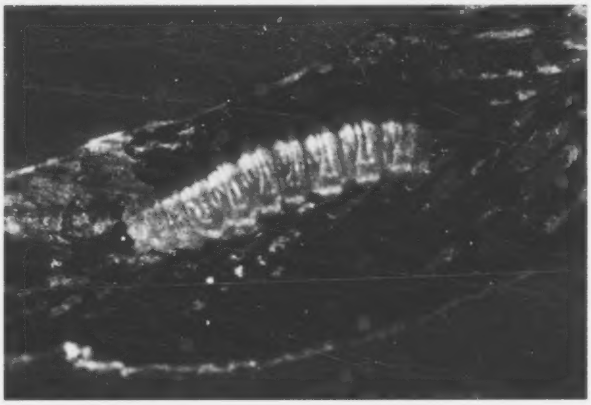
Most of the predators, parasitoids and diseases that attack the pea aphid will also attack these recently introduced species of legume-feeding aphids and probably play an important part in suppressing them. Most of the insecticides registered for control of pea aphid will also control other aphid species.

Alfalfa Weevil

The alfalfa weevil, *Hypera postica* (Gyllenhal) (Coleoptera: Curculionidae), is one of the most serious pests of alfalfa in North America. It was first found in Alberta in 1954 in the Milk River valley. Since then, it has spread throughout the southern parts of the prairie provinces.



ALFALFA WEEVIL ADULT (3 MM IN BODY LENGTH)



ALFALFA WEEVIL LARVA (5-7 MM IN BODY LENGTH) AND FEEDING DAMAGE ON ALFALFA

DAMAGE

Both adults and larvae feed on the above-ground parts of alfalfa, but most of the damage is caused by the larvae. The young larvae feed within the buds and unexpanded leaves at the apex of the plant. Even severe infestations at this stage are not readily apparent. Older larvae feed on open leaves near the terminal, and the resulting damage gives a severely infested field a grey appearance due to the drying-up of damaged leaves. Larval feeding usually peaks during the pre-bloom or early bloom stage. Very high populations of larvae can strip the plants leaving only skeletonized leaf fragments and stems.

Alfalfa weevils can reduce hay yields by up to 50 per cent and lessen hay quality. The yield of seed fields may also be greatly reduced, especially if moisture is inadequate for vigorous plant growth after the larvae have finished feeding. Overwintered adults feed sparingly on new growth in early spring, and new generation adults feed briefly after emergence in midsummer; however, damage by adults is rarely significant. Notching of leaf margins is characteristic of damage by adult weevils.

DESCRIPTION AND LIFE HISTORY

Adult alfalfa weevils are snout beetles about 5 mm long. There is only one generation a year in Alberta. Young adults, which first appear in late July, are light brown with a darker brown dorsal stripe extending from the head to about three-quarters of the way down the back. As the beetle gets older, the light brown scales are gradually rubbed off, and it becomes dark brown to nearly black and the stripe less apparent.

The adults overwinter in the crowns of alfalfa plants or amongst plant debris in or near alfalfa fields. In the spring, after the alfalfa begins to grow, the weevils emerge from hibernation, feed for a few days and then begin to lay eggs. The adults are quite mobile and can easily disperse to new fields.

The eggs are laid into alfalfa stems. The female chews a hole in the stem, then inserts the tip of her abdomen into the hole and lays a cluster of 5 to 20 eggs. The newly laid eggs are light yellow initially, becoming brown prior to hatching in 4 to 21 days depending on the ambient temperature. Each female can lay 400 to 800 eggs during a period of about a month or more.

The larvae are about 1 mm long when they emerge and go through four larval instars, molting three times, before becoming full grown larvae. All four instars have curved bodies and shiny black or dark brown heads. First instars are light yellow to yellowish green. Later instars are bright green, and the last two have a conspicuous white stripe down the middle of the back. Full grown larvae are 9 mm long. Larval development usually requires three to four weeks. The peak of larval activity usually occurs from mid-June to mid-July although some larvae are present throughout the summer.

Pupation occurs shortly after the peak in larval feeding. The dark brown or nearly black pupae are formed within loosely woven, lace-like white cocoons attached to the plant crowns or surface debris. The pupal stage lasts one to two weeks. New adults begin to appear in early July. From late June to the end of summer, young adults from the current year and some surviving overwintered adults from the previous year can both be found in alfalfa fields. The new adults feed on alfalfa for a short time before moving to hibernation sites in preparation for overwintering. The alfalfa weevil, and all other weevils that damage legume crops in Alberta, have only one generation each year.

CONTROL

An early first cutting of the alfalfa while the weevil is in the larval stage can greatly reduce the number of new adults. Many larvae are killed by the harvesting process, and others subsequently die of exposure and desiccation. Green chopping is the most effective harvest method because many larvae are removed from the field, and those that fall to the soil surface are immediately exposed to the elements.

Prompt removal of hay from windrows will also result in high larval mortality. If baling is delayed, the larvae can survive under the windrows until regrowth begins. In such situations, it is important to examine the regrowth for the presence of weevil larvae. If many are found, an insecticide treatment may be necessary to prevent suppression of the regrowth. Most of the adults and pupae present when the crop is cut will likely survive. Where permitted, controlled spring burning can sanitize fields by destroying insect eggs and resident overwintering stages plus it reduces the incidence of plant diseases.

Economic thresholds have been established for the use of insecticides under various scenarios: 20 to 30 alfalfa weevil larvae per 90° sweep (using a 38 cm (15 in.) diameter sweep-net) when 12 per cent leaf loss is acceptable or 50 to 75 larvae per 90° sweep when 30 per cent leaf loss is acceptable. Treatments should be applied when 25 to 50 per cent of leaves on the upper third of the stems exhibit damage or when 50 to 70 per cent of terminals show injury. Alfalfa seed crops may require insecticide control sooner, when weevil numbers exceed 20 to 25 third or fourth instar larvae per 90° sweep or when 35 to 50 per cent of foliage tips exhibit feeding damage.

Many insect predators and parasitoids attack alfalfa weevils. Unfortunately, the beneficial insect populations are devastated each time an insecticide is used. The most effective biological control agents are small parasitic wasps of which several species have been intentionally introduced. One species, *Bathyplectes curculionis* (Thomson), has proven quite effective in those areas where it has become established. Although known to be present in Alberta, the wasp's effect on alfalfa weevil populations has not been determined.

Weevil tolerant varieties of alfalfa have been developed in the United States, but none are suitable for the Canadian prairies.

Clover Leaf Weevil

The clover leaf weevil, *Hypera punctata* (Fabricius), another accidentally introduced species, feeds on several kinds of clover and alfalfa. In Alberta, this species usually occurs in low numbers and has been only an occasional pest of red and white clover.

DAMAGE

Both the larval and adult stages of the clover leaf weevil feed upon young stems and leaves. The larvae stay in the soil around the base of plants during the day and emerge at night, feeding mostly on lower leaves, chewing irregular holes in leaf margins. Most damage occurs in the early spring when the overwintered partially grown larvae resume feeding. There tends to be the most damage during cool, dry springs.

DESCRIPTION AND LIFE HISTORY

The clover leaf weevil adult is 6 to 8 mm long, considerably larger than the alfalfa weevil and lacks the dark dorsal stripe. The larvae are also larger and less greenish with a light brown head. The white dorsal stripe on the late instar larvae usually has a pinkish border. Unlike alfalfa weevils, the clover leaf weevils overwinter as larvae in the crown of the plant or in adjacent loose soil. They begin feeding again in early spring and when full grown, pupate in net-like cocoons just below the soil surface.

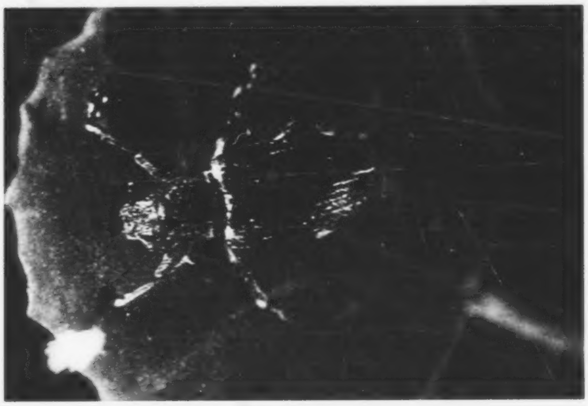
Adults emerge in early summer, feed sparingly for a short time and then enter a dormant summer state, termed aestivation. In the fall, they become active again, mate and lay eggs that hatch before winter.

CONTROL

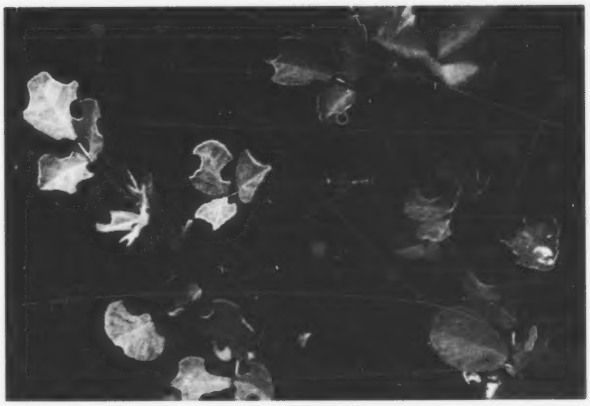
This species rarely causes economic yield losses in Alberta. Fields that show retarded or stunted early season growth should be examined for the presence of this species or others such as the alfalfa curculio.

Sweetclover Weevil

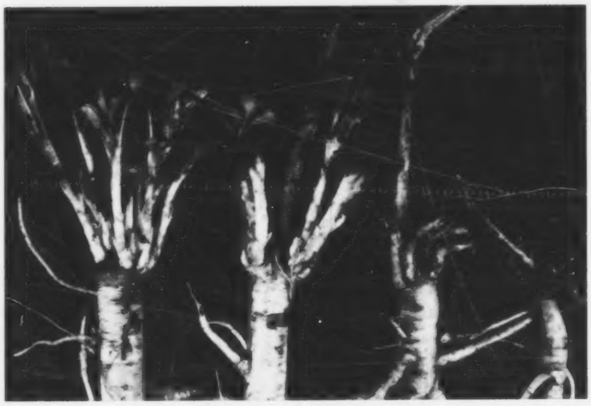
The sweetclover weevil, *Sitona cylindricollis* Fahraeus, is a European species that was first recorded in Canada in the early 1900's. It has been the main pest of sweetclover in western Canada since the 1930's. The adults feed on the leaves in the spring and fall, and the larvae feed underground on the roots during the summer.



SWEETCLOVER WEEVIL ADULT



SWEETCLOVER WITH NOTCHED FEED DAMAGE ON LEAVES



ROOT DAMAGE CAUSED BY SWEETCLOVER WEEVIL FEEDING (HEALTHY PLANT ON THE LEFT)

DAMAGE

Damage is done primarily by the adults, which chew crescent-shaped, jagged notches on the margins of leaves. This damage is characteristic and more easily observed than the weevils themselves, which drop to the ground when disturbed or approached. Damage is most severe in dry years.

Seedling stands can be destroyed by spring infestation, and first-year plants partially defoliated by fall infestation may lack winter hardiness. Second-year stands grown for forage can usually tolerate spring damage if moisture is adequate. However, seed fields can be damaged by fall infestation, which can defoliate entire plants as well as eating the outer layers of the stems and green pods. The adult weevils will also feed on, and can damage, seedling alfalfa or cicer milk-vetch when no sweetclover is nearby, but they can reproduce only on sweetclover.

Sweetclover Weevil

DESCRIPTION AND LIFE HISTORY

Adult sweetclover weevils are uniformly dark grey to black snout beetles about 5 mm long. They spend the winter under trash cover or in cracks in the soil in and around sweetclover fields. They become active in spring and feed mostly on sweetclover. The beetles mate in mid-May, and the females lay eggs on the soil surface near host plants.

The young larvae burrow into the soil and feed on root hairs and root nodules, but not on the taproot. The larvae are legless, greyish white with a light brown head and reach 5 mm in length before pupating 13 to 25 mm below the soil surface in an oval-shaped cell. Damage by the larvae appears to be unimportant. Larval development is completed in late July, and the mature larvae pupate just below the soil surface. The new generation adults emerge in mid-August and are capable of dispersing considerable distances to new sweetclover stands.

CONTROL

Economic thresholds in seedling sweetclover crops are one adult weevil per 3 to 5 seedlings in the cotyledon stage, depending on growing conditions, and 9 to12 adults per plant in newly emerged second year sweetclover. New stands of sweetclover should be sown as far as possible from second-year stands to reduce the risk of invasion by adults that disperse in spring or late summer.

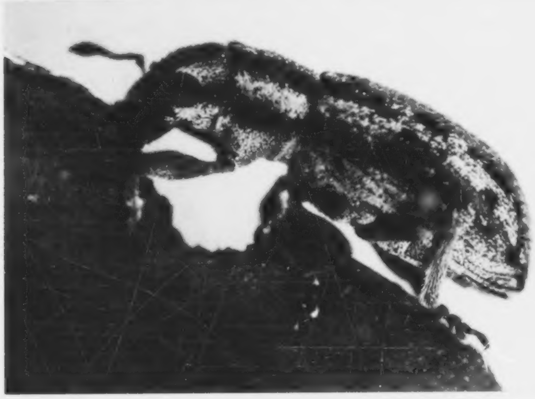
Sow high quality seed less than 2.5 cm (1 in.) deep into a firm, moist seedbed. Ideal seeding conditions encourage even, rapid emergence of competitive seedlings. If underseeding sweetclover to a canola cover crop, treatment of the canola seed with insecticide intended to reduce flea beetle damage may also decrease sweetclover weevil injury to the clover.

When new seedlings emerge, watch for signs of weevil damage. If damage is becoming severe, apply a recommended insecticide. In some cases, application of insecticide along a 20 to 30m strip at the field edge may be sufficient.

Under favourable moisture conditions, second-year sweetclover can outgrow damage caused by most infestations of the sweetclover weevil. Performing a shallow cultivation of second-year sweetclover immediately after it is cut for silage or hay will kill many larvae and some pupae.

Alfalfa Curculio

The alfalfa curculio, *Sitona lineelus* Bonsdorff (=*scissifrons* Say), is a native weevil that feeds on alfalfa, sainfoin, cicer milkvetch and some native vetches.



ALFALFA CURCULIO ADULT (UP TO 4 MM IN BODY LENGTH)

DAMAGE

The adults eat notches along the leaf margins of attacked plants. Infestation of seedling fields of sainfoin, cicer milkvetch or alfalfa may destroy the crop. Established stands are rarely damaged because the feeding is usually restricted to the lower basal leaves. However, established cicer milkvetch and sainfoin are sometimes damaged by the overwintered adults feeding on the crowns early in the spring, resulting in delayed shoot emergence. The young larvae feed on root nodules and root hairs, whereas the older larvae feed externally on the roots, which can result in decreased plant hardiness and an increase in the likelihood of infection by various plant diseases.

DESCRIPTION AND LIFE HISTORY

The alfalfa curculio adult, at 3 to 4 mm in length, is smaller than the sweetclover weevil and lighter in colour. The adult overwinters in trash in fields and headlands and begins to feed on the leaves of various legumes in early May. The adults mate during the spring and early summer, and the females lay eggs near the base of a host plant. When full grown, the subterranean larvae pupate near the soil surface. The adults emerge in late summer, feed for a while and then seek overwintering sites.

CONTROL

Sainfoin and cicer milk-vetch fields should be monitored closely during the spring. If seedling stands are being damaged, an insecticide may need to be applied. If new growth of established fields appears to be slow, the crowns should be closely examined for the presence of weevils, and if warranted, an insecticide applied. Once the shoots appear above ground, economic injury from alfalfa curculio is unlikely.

Clover Root Curculio

Another species of *Sitona*, the clover root curculio, *Sitona hispidula* (Fabricius), also occurs in southern Alberta, but has not been reported to cause significant damage. It can attack clover (*Trifolium* spp.), alfalfa and occasionally other legumes.

DAMAGE

Damage is similar to that caused by the alfalfa curculio described previously, except that the larger larvae tend to feed more extensively on the larger lateral and main tap roots, particularly in clover. This damage increases susceptibility to root and crown diseases, reducing the plant's ability to overwinter or withstand drought conditions. Leaf feeding by the adults is usually rarely of concern.

DESCRIPTION AND LIFE HISTORY

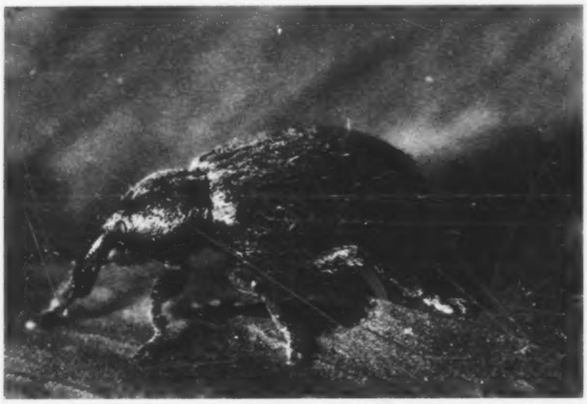
Adults are 4 to 5 mm long, black or brown with a grey underside. They are similar to, but slightly smaller than, the sweetclover weevil. Clover root curculio usually overwinter as adults, but sometimes as eggs or small larvae. Feeding damage occurs very early in the spring, and pupation typically occurs in April with new adults emerging in May or June. By October or November, new generation adult females will start to lay eggs within plant crowns although the majority of eggs are laid the following spring by overwintered females.

CONTROL

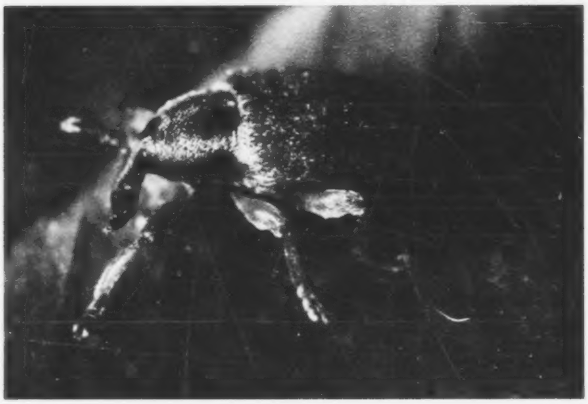
Cultural control measures for the clover root curculio include crop rotation and plowing infested clover stands in late fall or early spring.

Lesser Clover Leaf Weevil

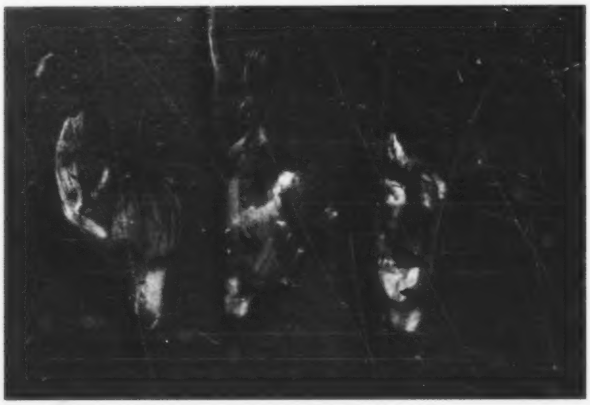
The lesser clover leaf weevil, *Hypera nigrirostris* (Fabricius), is another snout beetle that feeds on a variety of true (*Trifolium* spp.) clovers, although it is most damaging to red clover. The weevil rarely affects hay production, but can drastically reduce seed yields.



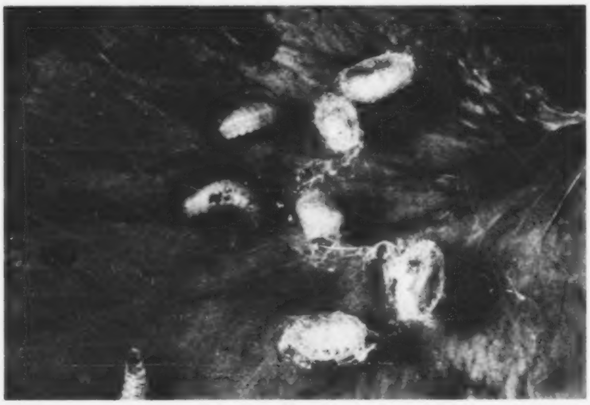
OVERWINTERED LESSER CLOVER LEAF WEEVIL ADULT (4 MM) WITH BLUE-GREEN TINGE OF COLOUR



NEWLY EMERGED SUMMER ADULT WITH BROWN COLOURING



FLOWER HEAD DAMAGE CAUSED BY LESSER CLOVER WEEVIL LARVAE



LESSER CLOVER LEAF WEEVIL LARVAE (UP TO 6 MM) PLUS PUPAE (5 MM), EACH ENCASED WITHIN CHARACTERISTIC COCOON

Lesser Clover Leaf Weevil

DAMAGE

Both adults and larvae feed on red, white, alsike and other clover species. Adults chew holes in leaves and leaf buds, but usually do not affect forage yields. Larvae feed preferentially on leaf and flower buds and prevent the heads from forming. Sparsely blooming fields may indicate lesser clover leaf weevil larval damage. Seed losses are usually greater in dry years than in wet ones.

DESCRIPTION AND LIFE HISTORY

The adult is only about 4 mm long. Newly emerged adults, which appear in mid to late July, are initially light brown, but gradually darken and develop a metallic greenish cast.

They overwinter in debris in clover fields and surrounding areas and move onto red clover when the plants start to grow in the spring. Females lay 200 to 300 eggs from early May to early June in stems, leaf buds and stipules.

The larva is a greyish to brownish yellow grub with a prominent dark head capsule, reaching 6 mm in length. Larvae feed for about three weeks, at first in stipules and later in flower heads. Larval populations peak as red clover reaches full bloom. Mature larvae pupate in silken cocoons in flower heads, leaf axils or in the crowns near the soil surface. New generation adults feed for a time before searching for overwintering sites.

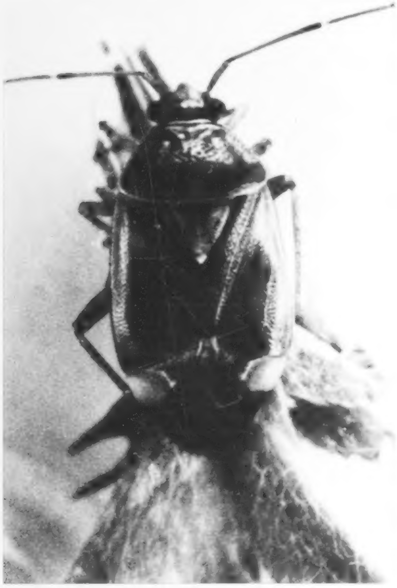
CONTROL

Several parasitoid insects and diseases help reduce weevil numbers. Rapid growth of the host crop will decrease the severity of weevil damage Where permitted, burning of red clover fields may decrease numbers of overwintering adults, but likely has a similar effect on beneficial parasitoids and predators.

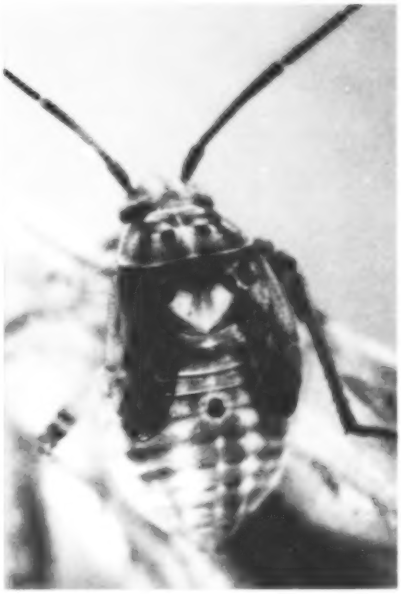
No economic thresholds for lesser clover leaf weevil have been established, but a single weevil larva feeding on a flower bud can prevent an entire flower head from developing. Larval densities greater than three per five shoots can damage up to 50 per cent of buds and flower heads. If this weevil has become a problem in a field, the best time to control it is to apply an insecticide in the spring after the adults have emerged from hibernation, but before they have had a chance to lay many eggs, or after pre-bud when most of the eggs have hatched, but before the larvae move up to the buds and flowers.

Lygus Plant Bugs

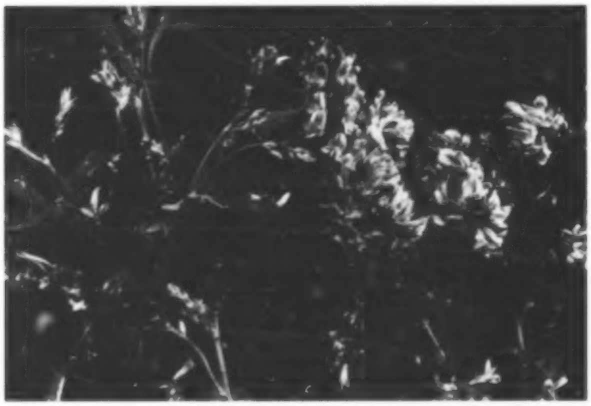
Lygus bugs can cause problems in alfalfa grown for hay but are of most concern as a pest in alfalfa seed production. They damage leaves, flowers and developing seeds of many kinds of plants. Several species of *Lygus* occur in Alberta, with the most common being *L. borealis* (Kelton), *L. keltoni* (Schwartz), *L. lineolaris* (Palisot de Bauvois) and *L. elisus* (Van Duzee). Both the nymphs and adults are very common on alfalfa.



LYGUS BUG ADULT (4 - 5 MM IN BODY LENGTH)

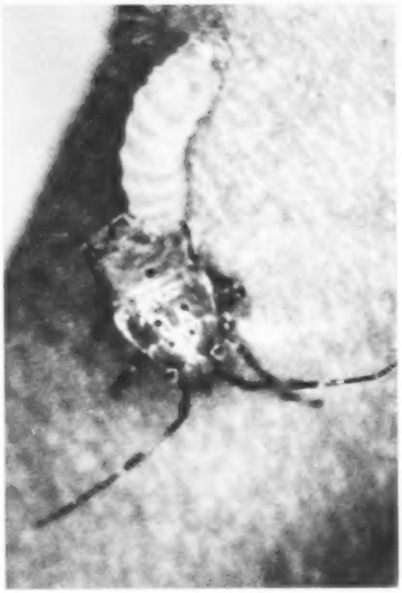


FIFTH INSTAR LYGUS BUG NYMPH (4 MM IN BODY LENGTH)



(LEFT) FEEDING DAMAGE CAUSED BY LYGUS BUGS RESULTING IN ABORTED BUDS AND REDUCTION IN FLOWERS – (RIGHT) NORMAL

Lygus Plant Bugs



LARVA OF PARASITOID WASP (2 MM) EMERGING FROM ABDOMEN OF LYGUS NYMPHAL HOST

DAMAGE

Lygus bugs have piercing-sucking mouthparts and physically damage the plants by puncturing the tissue and sucking the plant juices. In some cases, there is also a phytotoxic response to the saliva that they inject when feeding. Lygus bug infestations (over 15 per sweep) can cause alfalfa to have shortened internodes and racemes, excessive branching and small, distorted leaves.

Hot dry weather favours the build-up of populations and increases the possibility of damage, especially early in the season. Feeding on flower buds or young blossoms causes blasted buds and flower drop. The insects also puncture green seed pods to feed on the developing seeds causing them to turn brown and shrivel.

DESCRIPTION AND LIFE HISTORY

Adult lygus bugs are about 4 to 5 mm long and about 2 to 2.5 mm wide. They vary in colour from pale green through reddish brown to dark brown and have a distinct triangle about one-third of the distance down the back. There is also a seasonal colouration variation in all species with new summer adults being lighter in colour than those that overwinter.

The young nymphs are small, blue-green and look somewhat like aphids but are more active and have dark markings, either red, brown or black, on the antennae. The first three instars have a single dorsal black spot on the abdomen. The remaining two instars are darker in colour, have wing pads and four prominent black spots on the top of the thorax in addition to the one on the abdomen.

Lygus bugs overwinter as adults under crop residue, litter or other plant cover along fencelines, ditchbanks, hedgerows and wooded areas. In spring, the eggs are laid in the stems of alfalfa and other host plants. Overwintered females will continue to lay eggs for a month or more. The eggs hatch between the end of May and mid-July, about the time alfalfa begins to bloom. The nymphs reach adulthood after 20 to 30 days, depending on environmental conditions.

There is only one generation per year in the northern part of the province, but there are normally two generations per year in southern Alberta. Adults remain in the alfalfa until late summer when they move out of the fields to overwintering sites.

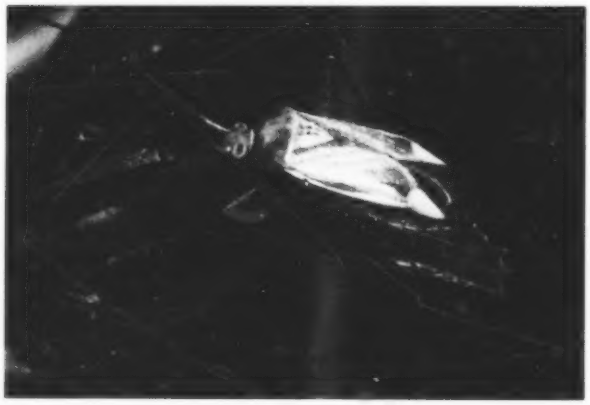
Lygus bugs feed and reproduce on many herbaceous plants, although alfalfa is the preferred host for several species. Important weed hosts in Alberta are flixweed, kochia, lamb's quarters, mustard, Russian knapweed and Russian thistle. All species feed preferentially on buds, flowers and developing seeds.

CONTROL

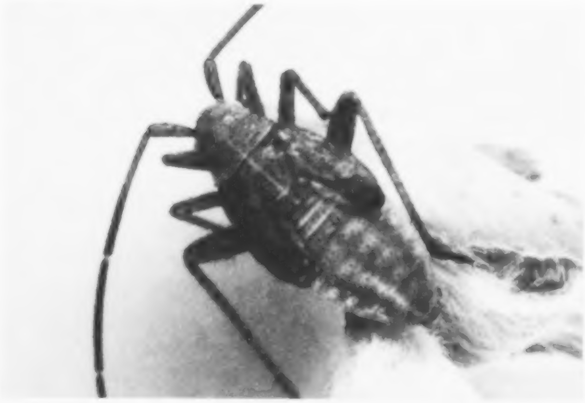
In most hay fields in Alberta, lygus bugs do not need to be controlled. An early first cut for hay or silage before the nymphs reach adulthood will reduce populations. Most common predators will feed on lygus nymphs, and several species of parasitoids are specific to lygus and plant bugs and are important natural biocontrol agents. Chemical control is sometimes necessary in alfalfa grown for seed. The economic threshold for lygus bugs in alfalfa seed crops is 8 lygus bugs per 180° sweep or 5 nymphs/sweep of any or all species of plant bugs when the alfalfa is in bud or in bloom. Chemical application should be timed so that the majority of nymphs are third instars or older.

Alfalfa Plant Bug

The alfalfa plant bug, *Adelphocoris lineolatus* (Goeze), is the main plant bug causing problems in seed alfalfa in Alberta, although damage to sainfoin and birdsfoot trefoil has also been reported. The rarer superb plant bug, *Adelphocoris superbus* (Uhler), is an infrequent pest.



ALFALFA PLANT BUG (8-9 MM IN BODY LENGTH)



ALFALFA PLANT BUG NYMPH AT FOURTH INSTAR STAGE (5 MM IN BODY LENGTH)

DAMAGE

Both species belong to the same family as lygus bugs and have similar habits. Alfalfa plant bugs feed on the buds, flowers and green seeds, which causes buds to become blasted and die, flowers to drop and seeds to shrivel and fail to germinate.

DESCRIPTION AND LIFE HISTORY

Adults of the alfalfa plant bug are 8 to 9 mm long, 2 to 2.5 mm wide and yellowish green to dark green. The superb plant bug is slightly smaller and red and black. There are five nymphal instars. The nymphs of the alfalfa plant bug are mid to dark green and those of the superb plant bug mostly red. They can be distinguished from nymphs of lygus bugs by the presence of an enlarged last antennal segment and the lack of dark spots on their back.

The life histories of the two species are similar. The eggs are laid into alfalfa stems and overwinter in the stubble and straw left in the field after harvest. The overwintered eggs hatch from the end of May to mid-June. The life cycle from egg hatch to adult takes about 30 days. In Alberta, there is usually only one generation per year, but in unusually warm summers, there can be a second generation.

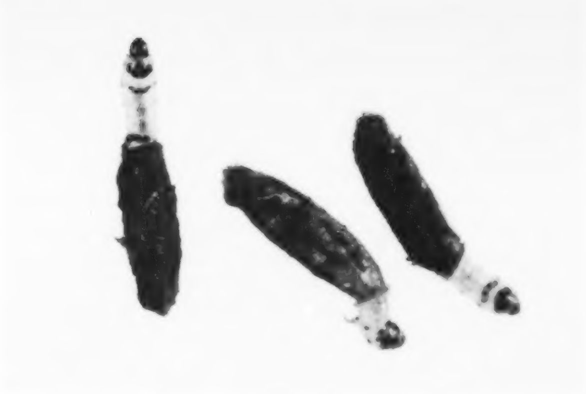
CONTROL

Burning of alfalfa stubble and crop residue in seed fields in late fall or early spring destroys the eggs laid the previous summer and fall. The management practices associated with harvesting of forage usually prevent the build-up of economic infestations of these plant bugs in hay fields.

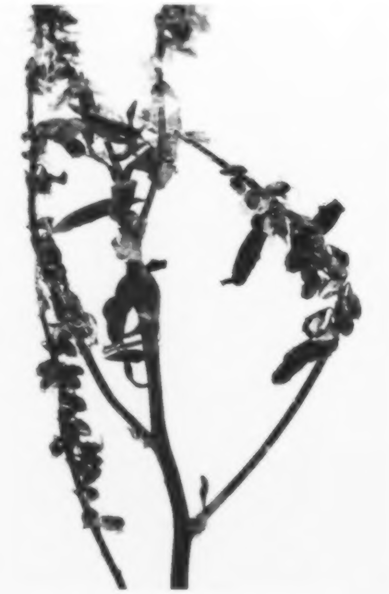
The economic threshold for alfalfa plant bugs is 2 to 3 fourth or fifth instar nymphs or adults per 90° sweep using a 38 cm (15 in.) diameter sweep-net or 4 fourth or fifth instar nymphs or adults per 180° sweep. Care is required when applying insecticides to alfalfa seed crops to avoid killing the bees that are required for pollination.

Legume-feeding Casebearers

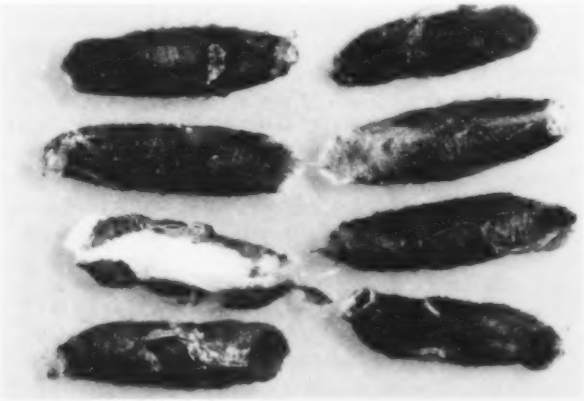
The larvae of several species of casebearer moths found in Canada feed on legumes. *Coleophora deauratella* Leinig and Zeller larvae feed on seeds of red and alsike clover, larvae of *C. mayrella* (Hübner) feed on seeds of white clover and those of *C. trifolii* (Curtis) on seeds of sweetclover. *C. accordella* Walsingham feeds on trefoils, and *Hedysarum* and larvae of *C. collutella* (F.) feed on leaves of crownvetch. The sweetclover casebearer, *C. trifolii*, is common in western Canada.



CLOSE-UP OF SWEETCLOVER CASEBEARER LARVAE, WHICH CARRY THEIR CASES AS THEY MOVE AND FEED ON A HOST PLANT



CASEBEARER LARVAE (UP TO 8 MM) FEEDING ON SWEETCLOVER



SWEETCLOVER LEAVES ROLLED INTO CASES (7 MM) BY CASEBEARER LARVAE

DAMAGE

Most casebearers are seed-feeders and can cause considerable losses in legume seed production, although *C. collutella* decreases crownvetch leaf biomass.

DESCRIPTION AND LIFE HISTORY

Adults of all the above species except *C. collutella* are small metallic green moths with a 9.5 to 15.5 mm wingspan, narrow wings and have hair fringes at the wing edges twice as long as the wing width. *Coleophora collutella* moth forewings are orange-brown to orange-yellow, with a dark brown apex.

Eggs are laid on the outer surface of the calyx or flower bracts; upon hatching, the larvae bore into the flower and feed on developing seeds. As they grow, they tunnel into adjacent florets, leaving small round holes near the base. A single larva can destroy two to three florets per day. Older instar larvae construct portable cases by cementing the petals of withered florets together with silk, gradually enlarging the case as they grow. The cases of mature larvae are cigar-shaped, brownish and about 6 mm long.

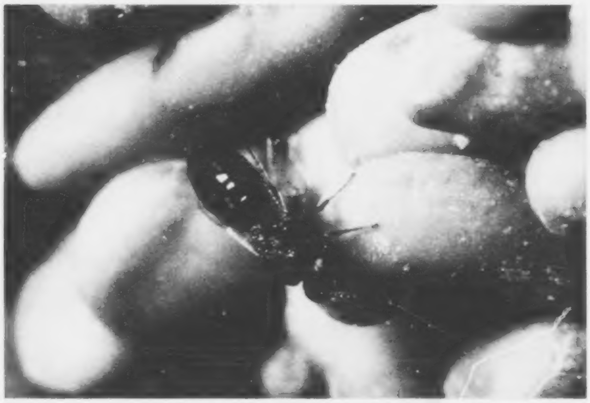
In late summer, the mature larvae seek overwintering sites on the ground. They seal the entrance of their case and overwinter in the larvae stage. Pupation occurs the following spring, and adults emerge in early summer. *Coleophora collutella* cases are constructed from vetch leaves. The larvae of this species overwinter on the plant; in spring, they feed on the undersurface of leaves, forming large white blotch mines. Pupation takes place in June, with moths emerging in early July.

CONTROL

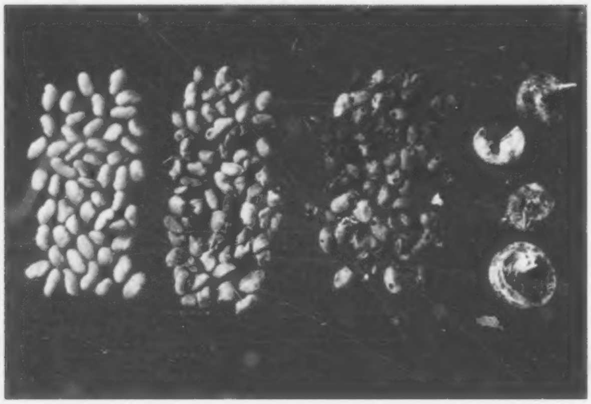
No insecticides are presently registered for the control of casebearers in clover. Natural predation and parasitism account for some mortality. A few cultural control methods can reduce casebearer populations including inter-row cultivation or light harrowing in the fall in stands of young plants. The physical disturbance can reduce larval numbers by exposing them both to the environment and predation.

Seed Chalcids

The alfalfa seed chalcid (*Bruchophagus roddi* (Gussakovsky)), the clover seed chalcid (*Bruchophagus gibbus* (Boheman)), the trefoil seed chalcid (*Bruchophagus platypterus* (Walker)) and the sainfoin seed chalcid (*Eurytoma onobrychidi* Walker)) are all tiny wasps whose larvae infest legume pods and destroy the seeds. The species are very similar in appearance and are generally identified by the host plant they attack.



ALFALFA SEED CHALCID ADULT (1.5 MM)



ALFALFA SEED CHALCID DAMAGE CONSISTING OF EMERGENCE HOLES MADE BY ADULTS EXITING THE SEED

DAMAGE

Seed chalcids do not affect legume forage production, but can cause up to 50 per cent reduction in seed yield. Lower than expected yields and the presence of seeds and seed pods with small round exit holes indicate damage by seed chalcids. At harvest, the extent of chalcid damage can go unnoticed since many damaged seeds are blown out of the combine along with the chaff. Crop damage under dryland conditions may be twice that under irrigation. Likewise, damage is usually worse the year following a hot, dry summer.

DESCRIPTION AND LIFE HISTORY

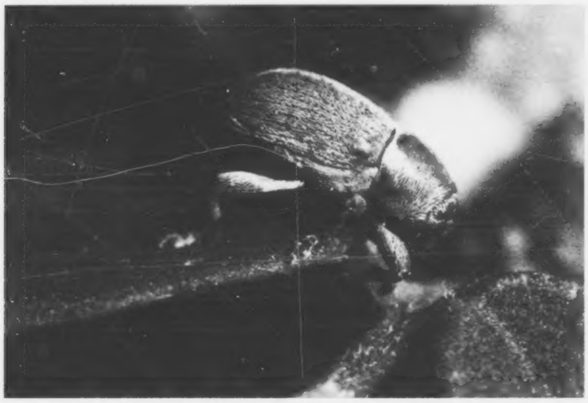
Adult chalcids are small wasps about 1.5 to 2.5 mm in length that are metallic black with dark brown legs. The tiny, white maggot-like larvae overwinter inside legume seeds within fields or in storage. The larvae pupate within the seed in the spring, and the adults emerge as the host crop begins to flower. Female wasps lay their eggs into immature pods, and the larvae feed on the developing seeds for about two weeks. The summer generation then pupates inside the hollowed-out seed coat, and adults chew their way out of the seeds and pods and proceed to lay eggs into younger green pods. These eggs hatch to produce the overwintering generation of larvae. Because the adults have a protracted period of emergence, all stages of the seed chalcids are present throughout most of the summer.

CONTROL

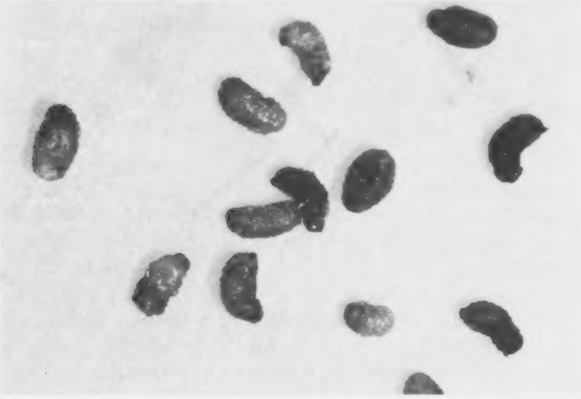
Adjacent volunteer alfalfa and clovers should be cut or destroyed before they set seed. Shallow cultivation of seed fields in the fall or early spring buries many chalcid-infested seeds. Combine tailings and screenings should be collected and destroyed or moved off farm. If burning is an option, straw and stubble should be burned shortly after harvest, before any regrowth occurs. Whenever possible, certified seed should be sown. Uncertified seed should be carefully examined for the presence of overwintered larvae within the seeds before use.

Clover Seed Weevils

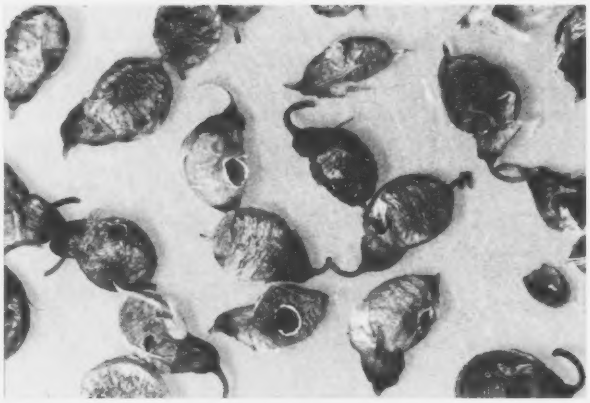
Three introduced weevils in the genus *Tychius* that are now present in Alberta feed on legume seeds. *Tychius picirostris* (Boisduval) feeds on white, alsike, ladino and red clover seed, *Tychius stephensi* Schönherr feeds mainly on seeds of red clover and *Tychius meliloti* Stephens feeds on seeds of sweetclover.



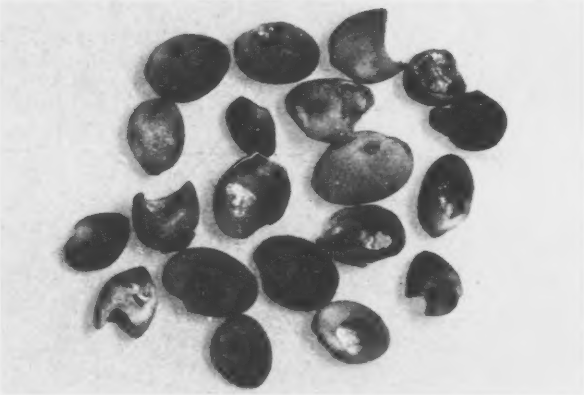
SWEETCLOVER SEED WEEVIL ADULT (2 MM) ON SWEETCLOVER LEAFLET



SWEETCLOVER SEED WEEVIL LARVAE (1.5-2 MM)



CLOVER SEED WEEVIL LARVAL FEEDING DAMAGE TO SWEETCLOVER PODS



CLOVER SEED WEEVIL LARVAL FEEDING DAMAGE TO SWEETCLOVER SEEDS

DAMAGE

Both the larvae and adults injure seed. Adults puncture the calyx to feed on the developing ovules and to lay eggs in the young seed pods. The larvae feed on developing seeds inside the pods.

DESCRIPTION AND LIFE HISTORY

Adults are small brownish snout beetles 1.7 to 2.6 mm in length, with scales on their wings arranged in longitudinal rows. These three species are the smallest weevils associated with clover. Adults overwinter under plant debris in and around clover fields. They emerge in late spring and feed on the clover as it begins to bloom.

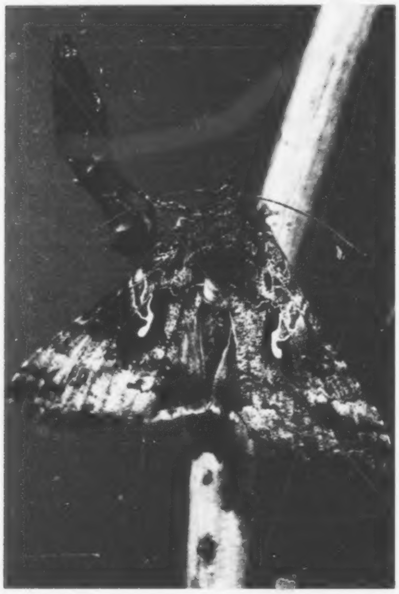
The cream coloured larvae feed in the seed pods until pod maturation. The mature larvae exit the pods and drop to the ground to pupate in the soil. The new generation adults emerge about two weeks later. There is only one generation per year on the Canadian prairies whereas two generations per year have been observed in the United States near New York.

CONTROL

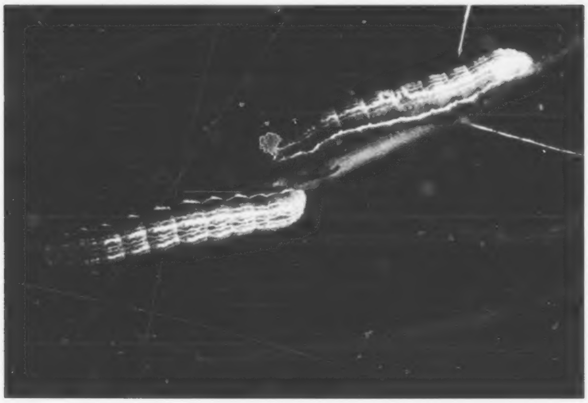
Few methods are available for clover seed weevil control. Seed weevil larvae normally exit the seed to pupate in the soil, and larvae should not be present within seed at harvest. Only certified seed free of weevil infestation should be sown. If seed weevils are present in a field, all the chaff and screenings should be destroyed.

Alfalfa Looper

Small numbers of alfalfa looper, *Autographa californica* (Speyer), can be found in alfalfa and other forage crops every year. However, local outbreaks occasionally occur, and damage can be severe.



ALFALFA LOOPER MOTH (WINGSPAN UP TO 40 MM)



ALFALFA LOOPER (25-30 MM IN LENGTH).
NOTE TWO ABDOMINAL PROLEGS THAT AID LARVA TO MOVE IN A LOOPING MOTION

DAMAGE

Alfalfa loopers are general feeders on broadleaf plants including forages, canola, many vegetables, flowers and fruit trees. Small larvae feed on leaf surfaces, medium-size larvae eat ragged holes through the leaves and larger larvae feed along leaf margins and can defoliate a plant and clip flowers and seed pods.

DESCRIPTION AND LIFE HISTORY

The young larvae vary from light to dark green and are only 1 to 2 mm long. The mature larvae, about 30 mm in length, are light to olive green with a pale head and whitish stripes, one down each side and two down the back. The larvae move with a looping motion. There are three pairs of true legs on the front of the body directly behind the head. In addition, there are two pairs of peg-like pro-legs about two thirds of the way down the body and another pair on the last segment.

When the larva is mature, it spins a white, woolly cocoon, often attached to the host plant, in which to pupate. The developing pupa within the cocoon is initially green, gradually turning dark brown. Adult moths have predominately grey forewings with a distinct white sickle-shaped spot near the middle of each wing. The body and hind wings are dull grey or brown.

The alfalfa looper overwinters in the pupal stage in the soil or under plant debris. The moths usually emerge in late April or early May, but because they fly at dusk and early night, they are seldom seen. There are two to three generations per year and the generations often overlap. The white to cream coloured eggs are laid singly or in small groups on the underside of leaves of host plants. Development from egg to adult requires 30 to 40 days.

CONTROL

The alfalfa looper is usually held in check by its natural parasitoids and predators and by a virus disease that often kills the larvae before they can pupate. When damage is becoming severe, effective insecticides are available.

Alfalfa Caterpillar

The alfalfa caterpillar species *Colias eurytheme* (Boisduval) is resident in Alberta but is usually only of minor importance because its populations are usually kept low by natural biological controls. The adult is a common yellow butterfly.

ALFALFA CATERPILLAR LARVA
(UP TO 30 MM IN BODY LENGTH)

DAMAGE

The larval stage of the alfalfa caterpillar feeds on leaves of alfalfa and some other legumes, but rarely causes economic harm. They have occasionally been a problem in green peas because the larvae are difficult to remove mechanically during processing.

DESCRIPTION AND LIFE HISTORY

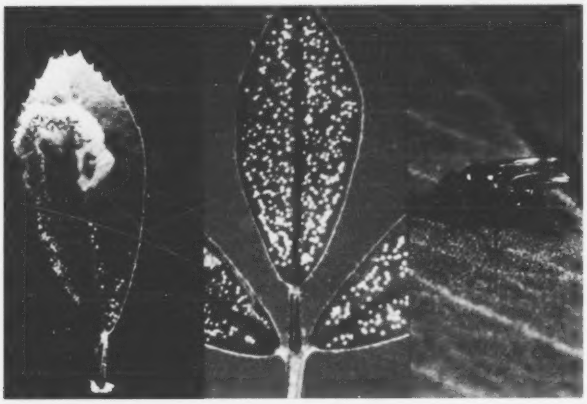
The larvae are velvety dark green with a white stripe along each side. They are about 30 mm long when fully grown. The yellowish green pupae (chrysalis) lack a cocoon and are attached, head end up, to the stem of the host plant. The adult is a day-flying butterfly with a wingspread of about 45 mm. Most are yellow or orangey yellow with black borders on the upper surface of the wings. They are sometimes common in late summer and fall. The elongate eggs, which are laid singly on the upper surface of leaves, are white when first laid but darken before hatching. There are normally several generations per year, overwintering as pupae.

CONTROL

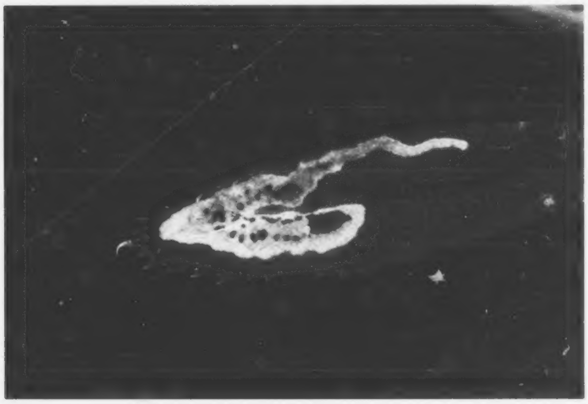
Alfalfa caterpillars are heavily attacked by parasitic flies and wasps and are often killed by disease. Normal forage harvesting disrupts the life cycle by preventing many larvae from maturing.

Alfalfa Blotch Leafminer

The alfalfa blotch leafminer, *Agromyza frontella* (Rondani), is an introduced species first found in Alberta in 2005. While slowly spreading westward after its initial detection in Massachusetts in 1968, it has caused heavy yield and quality losses in areas where it is not being controlled by natural enemies.



LARVAL FEEDING DAMAGE BY THE ALFALFA BLOTCH LEAFMINER (WINDOW AND TUNNELING), POKE HOLE DAMAGE ON ALFALFA LEAF AND ADULT STAGE (4 MM)



ALFALFA BLOTCH LEAFMINER FEEDING DAMAGE (WINDOW AND TUNNELING) BY LARVA (UP TO 4 MM)

POKE HOLES IN ALFALFA LEAF CAUSED BY ALFALFA BLOTCH LEAF MINER

DAMAGE

Alfalfa blotch leafminers can reduce alfalfa forage yields by 7 to 20 per cent and protein content by 10 to 20 per cent. Both adults and larvae are injurious. Females feed by puncturing leaves with their ovipositors, creating characteristic pinholes and then consuming the exuding plant sap. A single female creates an average of 3,700 pinholes during her lifetime.

Larvae emerging from eggs form distinctive question-mark-shaped mines as they feed within the leaf. Up to 70 per cent or more of the leaflets within a field may be attacked. Infested fields take on a whitish cast due to the larval mines in the leaflets. The wounds also increase the susceptibility of alfalfa to diseases, especially spring black stem.

Alfalfa Blotch Leafminer

DESCRIPTION AND LIFE HISTORY

The adult alfalfa blotch leafminer is a small black fly about 3 mm long. The eggs are laid on the leaflet surface. After hatching, the small, yellow larva tunnels between the upper and lower surfaces of the leaflet. As the larva grows larger, the tunnel increases in size until a significant portion of the leaf has lost its chlorophyll. Once it matures, the larva emerges from the "blotch," drops to the ground and pupates on the soil surface. Several generations can be produced within a year resulting in damage throughout the growing season. The leafminer overwinters as a puparium on the soil surface amongst plant litter.

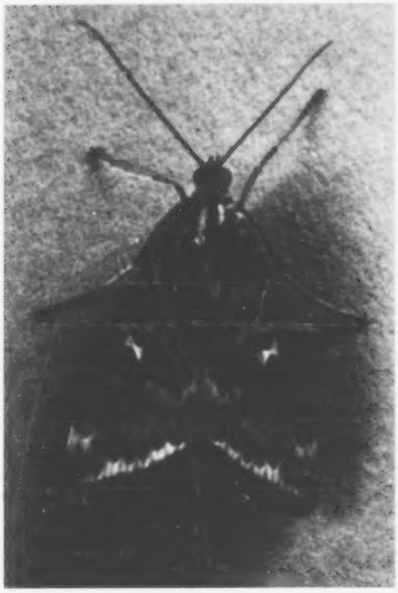
CONTROL

Biological control of alfalfa blotch leafminer has been extremely successful in eastern Canada where infestations are being suppressed below economically damaging levels by an introduced parasitic wasp, *Dacnusa dryas*. The parasite has reduced populations of alfalfa blotch leafminer by 98 per cent within 5 years of its introduction to areas where infestations had previously been severe.

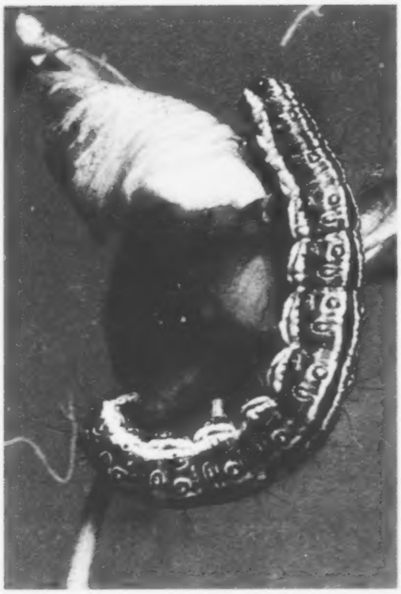
Several insecticides are registered in Canada for alfalfa blotch leafminer control. Treatment may be necessary if 30 to 40 per cent of the plants exhibit pinhole feeding damage. If insecticides are required, application should be made at the pinhole stage. Some authorities suggest insecticide application if 50 per cent or more of alfalfa leaflets exhibit leaf blotch mining. However, contact insecticides may be ineffective once the larvae have started mining.

Webworms

The larvae of several web-forming moth species can infest forage legumes. The beet webworm *Loxistege sticticalis* L., the alfalfa webworm *Loxistege cerealis* (Zeller) and the garden webworm *Achyra rantalis* (Guenee) are general feeders on broadleaf plants that occasionally reach high numbers in alfalfa.



ADULT BEET WEBWORM (WINGSPAN TO 18 MM)



BEET WEBWORM LARVA (TO 25 MM), WHICH CAN BE IDENTIFIED BY THE TRIO OF BLACK SPOTS OCCURRING ON THE SIDE OF EACH ABDOMINAL SEGMENT

DAMAGE

The larvae of these webworms are foliage feeders that spin webs amongst the leaves on the upper part of the plant on which they are feeding, hence the name webworms. Beet webworms sometimes move en masse into alfalfa fields from nearby crops or weedy areas after weed hosts are defoliated or killed by herbicides. If numbers are high, forage yields can be affected. Seedling crops are more vulnerable to injury than well established ones.

DESCRIPTION AND LIFE HISTORY

Adults of the above species of webworms are small, buff, greyish brown or brownish moths with a wing span of about 20 mm. Sometimes, they fly up in large numbers during the day when disturbed in infested crops or along weedy roadsides. The larvae are slender, dark green caterpillars with a broad yellowish stripe along each side and two narrow white stripes and distinct dark spots on their backs. Fully grown larvae are about 25 mm in length.

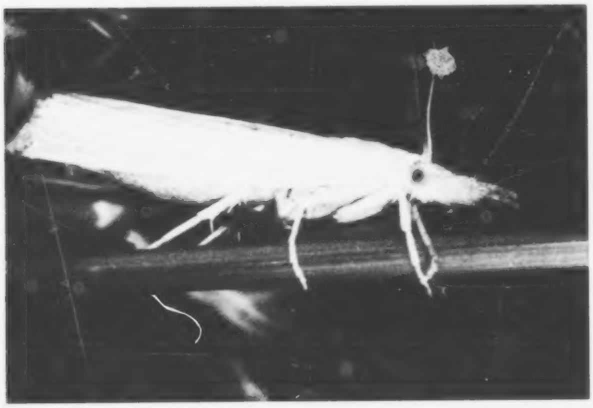
Normally, there are one or two generations per year, with first generation adults flying in May and June and second generation ones flying in late July and August. First generation larvae are most active in July and the second generation ones in late August and September. The second generation larvae overwinter in tubular silken cocoons just below soil surface and then pupate in early spring.

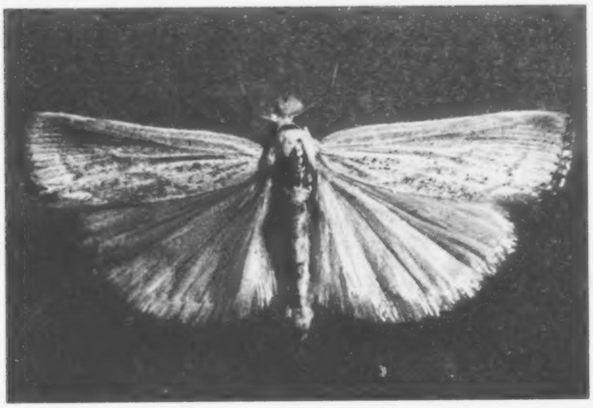
CONTROL

Destroying weeds early in the season helps to keep webworm numbers low because weeds such as lamb's quarters and Russian thistle are preferred food plants. Early cutting of infested hay fields usually provides adequate control. In infested seedling stands, an insecticide may need to be applied, preferably during the early instars, before extensive webbing has occurred.

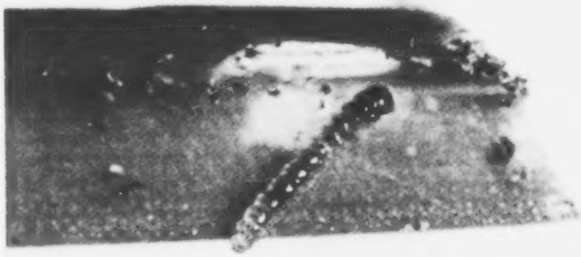
Sod Webworms

Sod webworm is a common name applied to the grass-feeding larvae of several species of small moths. They are mainly a pest of lawns and turfgrass, but occasionally damage established grass pastures or seed fields.

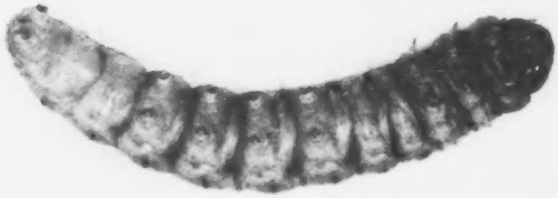




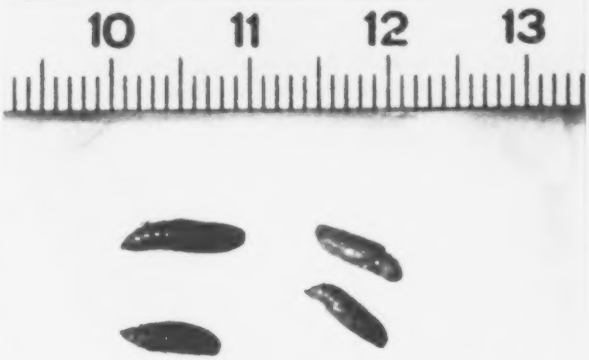
THE ADULT SOD WEBWORM (WINGSPAN TO 20 MM) HOLDS ITS WINGS FOLDED OVER THE BODY WHILE AT REST



EARLY INSTAR SOD WEBWORM LARVA (2-15 MM IN BODY LENGTH) AND FEEDING DAMAGE



SOD WEBWORM LARVA (UP TO 20 MM IN BODY LENGTH)



REDDISH BROWN SOD WEBWORM PUPAE (8 MM)

Sod Webworms

DAMAGE

Sod webworms feed on a wide range of grasses, including creeping red fescue, bluegrass, timothy and corn. The larvae feed at night on grass by clipping and consuming leaf blades from within silken tunnels in the thatch. Damage often appears as irregular brown patches within a field. Occasionally, blackbirds, robins or gulls will aggregate on infested patches to feed on the larvae. Suspect areas of grass should be examined for the presence of freshly clipped leaf blades or green fecal pellets at the soil surface, which indicate recent sod webworm activity.

DESCRIPTION AND LIFE HISTORY

Sod webworms belong to a large family of moths known as pyralids although most species are no longer in the genus *Crambus*. Several species have been associated with damage in sod and grass seed fields. *Pediasia aridella* (Thunberg) was present in severely damaged grass seed fields in the Peace River region.

Sod webworms overwinter as partially grown larvae in silk-lined nests several centimeters deep in the soil or thatch. In spring, the larvae resume feeding until they pupate within silken cocoons during June to August. The adults, sometimes referred to as snout moths because their mouthparts project forward appearing snout-like, emerge in late summer and fall. They are tan to grey with a wingspan of 15 to 20 mm. When at rest, the wings are folded around the body in a tube-like fashion. The oval, white eggs are laid individually at the base of grass stems at night. The eggs hatch in about a week, and the young larvae feed into the fall before overwintering.

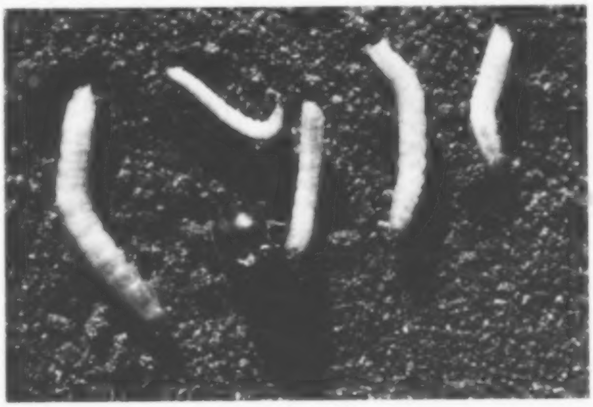
CONTROL

Irregular patches in grass seed fields or pastures that are brown or fail to green-up in the spring should be examined closely at the crown and soil surface level for evidence of damage or the presence of the larvae. Sod webworm damage typically occurs in irregular patches within a field, whereas winterkill, which it resembles, often affects large portions of a field. Beneficial predators, parasitoids and disease normally suppress populations below economically damaging levels.

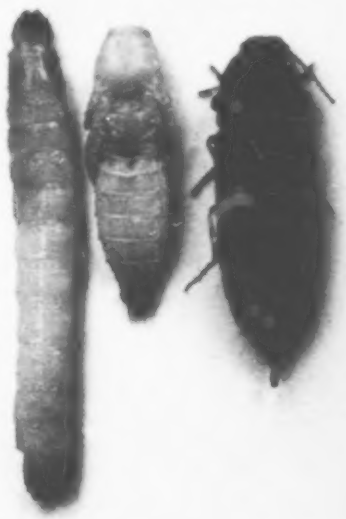
There is no accepted economic threshold for this pest in grass seed or forage. For turfgrass, the action threshold is 15 or more larvae per square meter. Treatment of turfgrass with insecticides is successful when they are applied using high water volumes or followed by sprinkler irrigation. Treatment with pyrethrins or synthetic pyrethroids causes the webworms to come to the surface

Wireworms

Several species of wireworm occasionally damage forage crops in Alberta. These are the same species that damage other field crops and include species in the genera *Ctenicera*, *Hypolithus* and *Limonius*.



EXAMPLES OF WIREWORM LARVAE (UP TO 30 MM IN BODY LENGTH) AND ITS ADULT CLICK BEETLE (8 TO 15 MM IN BODY LENGTH)



LARVAE, PUPA, ADULT

DAMAGE

Wireworms feed on roots or germinating seeds. Feeding on germinating seeds and seedlings can cause thin stands in the establishment year. Wireworms injure seedlings by rasping and shredding the stems below ground level, but do not cut off the stems as cutworms do. Damaged plants soon wilt and die. Sometimes, the outer leaves of older plants remain green for some time after the central shoot has died. Most damage occurs in early spring. Damage is likely to be more severe in crops seeded into newly broken grassland.

DESCRIPTION AND LIFE HISTORY

Wireworms are the larval stage of click beetles. Adult click beetles are elongate, black or brown beetles ranging in length from 5 to 15 mm. They can be easily identified by their ability to spring into the air with a clicking sound when placed on their backs.

In May and June, each female lays several hundred eggs up to 15 cm (6 in.) deep in loose soil or under lumps of soil. The young larvae are yellowish white. Older, amber coloured larvae are slow moving and hard bodied. Depending on the species, fully mature larvae are from 10 to 25 mm in length with a flattened, notched 'tail.' The larvae take 3 to 10 years to reach maturity, depending on availability and quality of food. They overwinter in the soil at depths of up to 50 cm (20 in.), moving to near the surface each spring to feed and returning to lower depths when the surface layers of soil warm up and dry out. Wireworms generally remain higher in the soil profile in irrigated fields than in dryland ones.

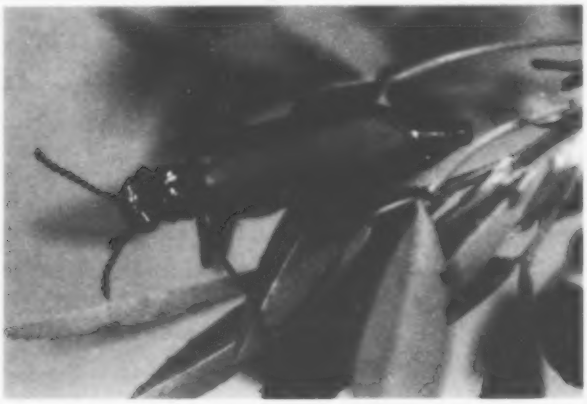
At maturity, they pupate in late summer in the top 10 cm (4 in.) of soil. The duration of the white, delicate pupal stage is less than a month, but the new adults do not emerge from the soil until the following spring.

CONTROL

The only effective method of controlling wireworms is to use an insecticidal seed treatment with an annual crop, preferably a cereal. Wireworms tend to be most abundant in fields that have been in grass for many years. They tend to be less abundant in fields that have been in alfalfa, but not clover, for several years.

Blister Beetles

About 15 species of blister beetles occur in Alberta. On the whole, they are considered beneficial insects because the larval stages of most species feed on grasshopper eggs. However, the larvae of some species feed on the larvae of wild bees, and one species occasionally infests the nests of the alfalfa leafcutting bee. Blister beetle numbers peak in years towards the end of, or just following, a grasshopper outbreak.



ADULT NUTTALL'S BLISTER BEETLE (30 MM) RESTING ON ALFALFA

DAMAGE

The adult blister beetles sometimes congregate in localized swarms in legume or canola crops and can strip leaves or entire plants in a very short time. Infestations are usually limited to small areas of a field and rarely cause economic damage to forage legumes. However, they can cause problems as a contaminant in hay because their bodies contain an alkaloid called cantharidin, which is toxic to livestock, particularly horses, when the dead bodies of the beetles are ingested with hay. This problem has become more prevalent with the use of hay conditioners that crush the beetles. Although this problem has become serious in some parts of the United States, it has not been a problem in Canada.

DESCRIPTION AND LIFE HISTORY

Blister beetles overwinter as larvae within the soil and pupate in the spring. Adults of most species emerge in June and July. They are elongate, soft-bodied beetles ranging from 12 to 25 mm in length, depending on species. The head is quite broad and set off from the winged part of the body by a narrow thorax. Several species are metallic black, greenish or bluish purple. Others are grey or brown and may have spots or stripes.

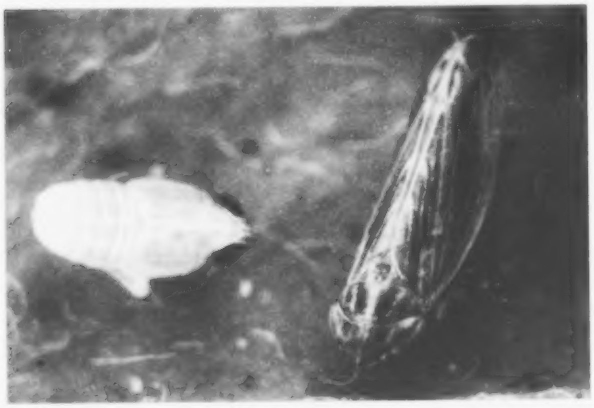
The eggs are laid in clusters in the soil, usually in an area frequented by a potential host, and hatch in two to three weeks. The first instar larva is very mobile and actively searches for a suitable host, which for most species is a grasshopper egg pod. Subsequent instars change considerably in form and appearance as they develop. The sixth, and final, instar is yellow and tough-skinned with greatly reduced mouthparts and legs. There is only one generation per year in Alberta.

CONTROL

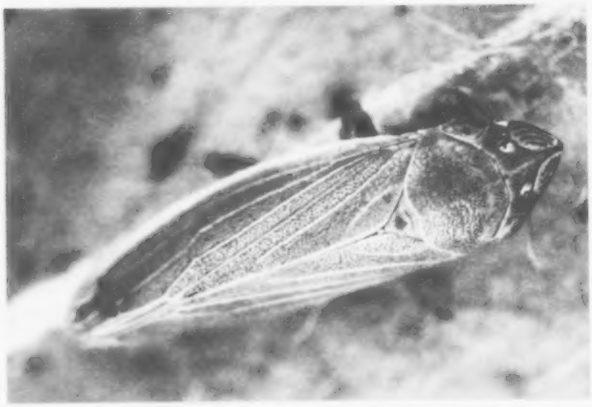
Blister beetles are usually a problem only after several years of a grasshopper outbreak. Cutting hay before 5 to 10 per cent bloom will usually ensure a beetle-free product, as adults are attracted to fields that are blooming. If beetles are present in considerable numbers at the time of cutting, the use of a hay crimper or conditioner that would crush the beetles and incorporate them into the swath should be avoided. If necessary, most recommended insecticides will give good control of this insect. Since infestations are usually concentrated near the edge of a field, an edge or spot application of insecticide may be all that is necessary.

Leafhoppers

Leafhoppers cause direct damage by their feeding and ability to transmit virus diseases affecting forage and other crops. Forage diseases transmitted by leafhoppers include alfalfa dwarf, clover big vein, clover phyllody, clover proliferation and clover yellows. In Alberta, many species of leafhopper are present, but none seem to cause problems to forages either by direct feeding or by disease transmission. However, in some areas of the eastern and central United States, leafhoppers are rated among the most serious pests of alfalfa.



LEAFHOPPER NYMPH (LEFT, 2 MM)
AND ADULT (RIGHT, 5 MM)



LEAFHOPPER ADULT (4 MM IN BODY LENGTH)

ALFALFA DISPLAYING "HOPPERBURN" CAUSED BY LEAFHOPPERS, WHICH IS CHARACTERIZED BY LEAVES TURNING YELLOW AND EVENTUAL SENESCENCE OF THE PLANT

DAMAGE

Leafhoppers are piercing-sucking insects; both the adults and nymphs suck the sap from plant leaves and stems. The potato leafhopper, *Empoasca fabae* (Harr.), introduces a toxin with its saliva as it feeds, which causes symptoms known as hopperburn: alfalfa leaf tips and margins curl up and turn yellow, eventually becoming brown and brittle. Heavy infestations can stunt alfalfa growth and reduce forage yield. Heavy infestations of grass-dwelling leafhoppers such as *Amphlicephalus inimicus* (Say) can cause white flecking on grass foliage and missing seeds in grass panicles. Various leafhopper species have been implicated in the appearance of silvertop or sterile seed heads in grasses.

DESCRIPTION AND LIFE HISTORY

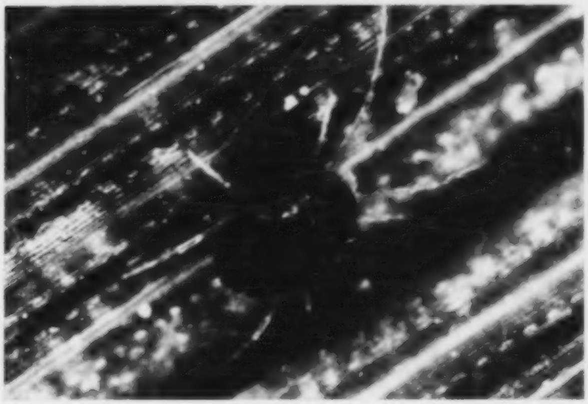
Leafhoppers are wedge-shaped insects, usually about 3 to 5 mm long and typically green to sand coloured. At rest, adults fold their wings over their backs in a tent-shaped manner. They can accumulate in large numbers in grasses and fly or hop away when disturbed. Some leafhoppers can overwinter in Alberta, usually as eggs, while others migrate as adults in the spring from southerly areas. There may be one or several generations per year, depending on leafhopper species and weather.

CONTROL

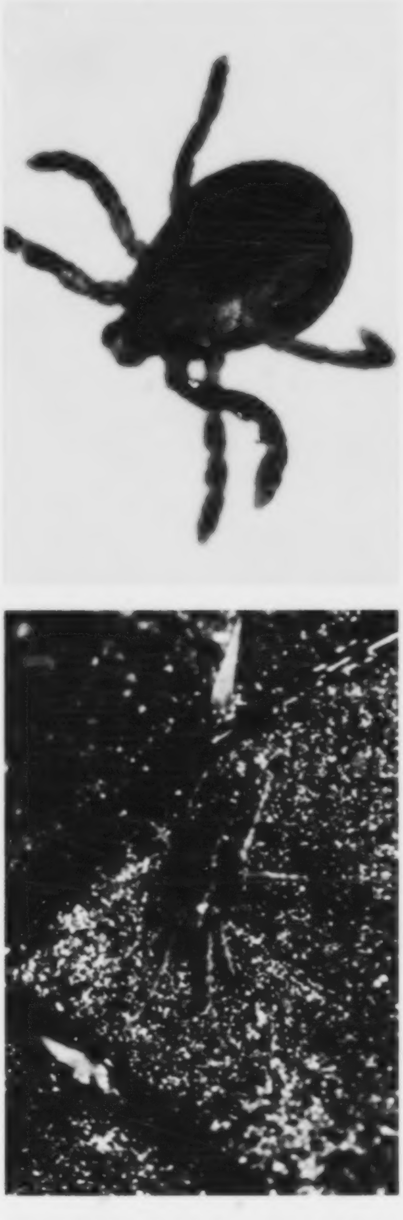
Predators of leafhoppers include birds, spiders, robber flies, some moths, wasps and assassin bugs. Parasitoids include species of wasps and flies. Early and regular cutting of alfalfa keeps leafhopper populations from building. In areas where they are a pest of economic importance, thresholds of potato leafhoppers in alfalfa are reported as 100 leafhoppers per 100 sweeps of an insect net when the alfalfa is 20 to 25 cm (10 in.) tall, and 200 when the alfalfa is 30 to 35 cm (12 - 14 in.) tall.

Mites

Mites, mainly the two-spotted spider mite, *Tetranychus urticae* Koch, are rare pests of alfalfa grown for forage. They prefer mature or senescing foliage and can be a problem in seed crops. Other mites found in forages include clover mite, *Bryobia praetosa* Koch, which, despite its name, can be a pest in turf and lawns. This mite species has been implicated in the occurrence of silvertop or sterile seed heads in grass seed production. *Petrobia latens* (Müller), the brown wheat mite, is an occasional pest of grass crops on the prairies. Normally a problem after a series of dry years, this pest was noted in 2005 in a timothy field in Alberta.



BROWN WHEAT MITE (1 MM IN BODY LENGTH)



TWO SPECIES OF MITES (1 MM IN BODY LENGTH)

Mites

DAMAGE

Mites concentrate on the underside of leaves where they feed and leave trails of webbing. Damaged areas become stippled with dark flecks and eventually turn brown and dry, causing affected leaves to drop from the plant. Mites gradually move up the plants and cluster at plant terminals, where they spin webbing over the flowers and leaves.

Dry conditions strongly favour mite biology. Drought-stricken plants alter their biochemistry to cope with the absence of water. The altered plants become more nutritious to spider mites, which increase their feeding rates in the arid conditions that also typically hinder their natural enemies.

DESCRIPTION AND LIFE HISTORY

Mites are barely visible to the naked eye. The two-spotted spider mite is less than 1 mm long, has eight legs, is sparsely covered with hairs and has two dark areas on either side of its body. Eggs are spherical, translucent, almost colourless and are laid amongst the feeding mites on the underside of leaves. Mites are often blown between plant branches or to new plants on strands of webbing. The adults overwinter under debris in or near fields or in cracks in the soil.

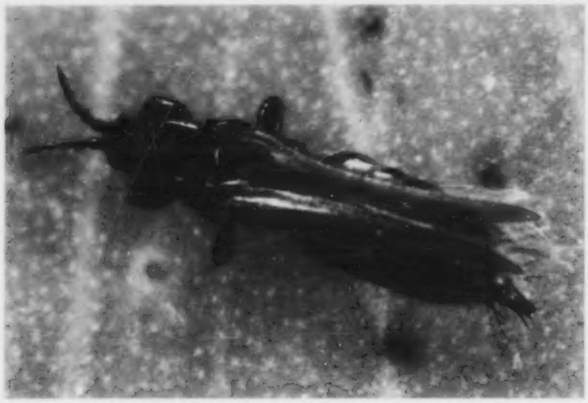
CONTROL

Mites are typically controlled by natural enemies including predatory mites, predatory thrips, minute pirate bugs and other insect predators. Irrigation and moisture management (such as no-till) can aid in mite control. When mite populations become a problem, the use of a recommended miticide can control damage.

The webbing that mites produce offers some protection from adverse environmental conditions, predators and foliar applications of insecticides. Thus, it is critical that adequate water volumes and spray pressure are used when attempting to obtain good mite control.

Thrips

Thrips occur on forages, especially on flowers, in very large numbers. The most common species are the flower thrips, *Frankliniella tritici* Fitch, on alfalfa; the grass thrips, *Anaphothrips obscurus* (Mull.), on grasses and the red clover thrips, *Haplothrips leucanthemi* (Schrank), on red and alsike clover.



THRIPS ADULT (1 MM IN BODY LENGTH)

DAMAGE

Because thrips are extremely small, the damage they cause can go unnoticed unless care is taken to monitor plant material. Their rasping-sucking mouthparts scarify tissue surfaces and disrupt cell growth. Damage to the plant cells causes shriveled, malformed or blasted growing points and is evident often as whitish blotches on leaves, buds, and petioles or discoloured florets.

In forages, thrips will feed within flowers, causing damage to floral structures that later results in low seed production. Thrips also feed within leaf sheaths and developing seed heads and have been associated with silvertop or panicle sterility in grasses. Thrips thrive in warm, dry weather, and infestations are usually heaviest in dry years. Generally, the older the stand, the heavier the thrips infestation, whereas stands cropped in the first year usually have few thrips.

DESCRIPTION AND LIFE HISTORY

Adult thrips are less than 2 mm long, very slender and have narrow wings fringed with long slender hairs. They are of various colours, from yellow to brown to black. Thrips larvae are similar in shape to the adults but are smaller, lighter in colour and lack wings. Thrips overwinter as adults or larvae in plant debris within fields and along headlands. Adults become active in spring and lay their eggs in slits they cut in leaves or petals of suitable host plants.

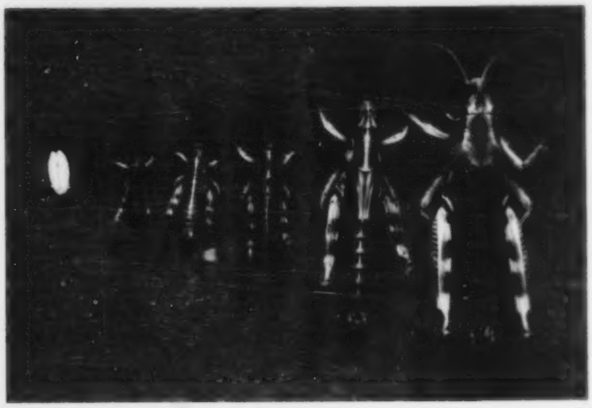
Eggs hatch in about seven days, and larvae feed actively for several days. They moult and then drop to the ground to pupate. After emergence, the adults mate and either remain on the original host or fly to a new host where they found subsequent generations. There are several generations per year with each generation requiring three to four weeks to complete.

CONTROL

Thrips are usually kept under control in forages by predators including anthocorid bugs, predatory thrips and ladybird beetles. In legumes, numbers as high as one thrips per floret (e.g. 50 - 80 or more per clover raceme) have failed to cause decreases in seed yield. Insecticide control is difficult because of the detrimental effects on pollinators and because the thrips are well sheltered inside flowers and leaf sheaths. In grass seed production, removal of old growth in fall or spring may help reduce thrips populations.

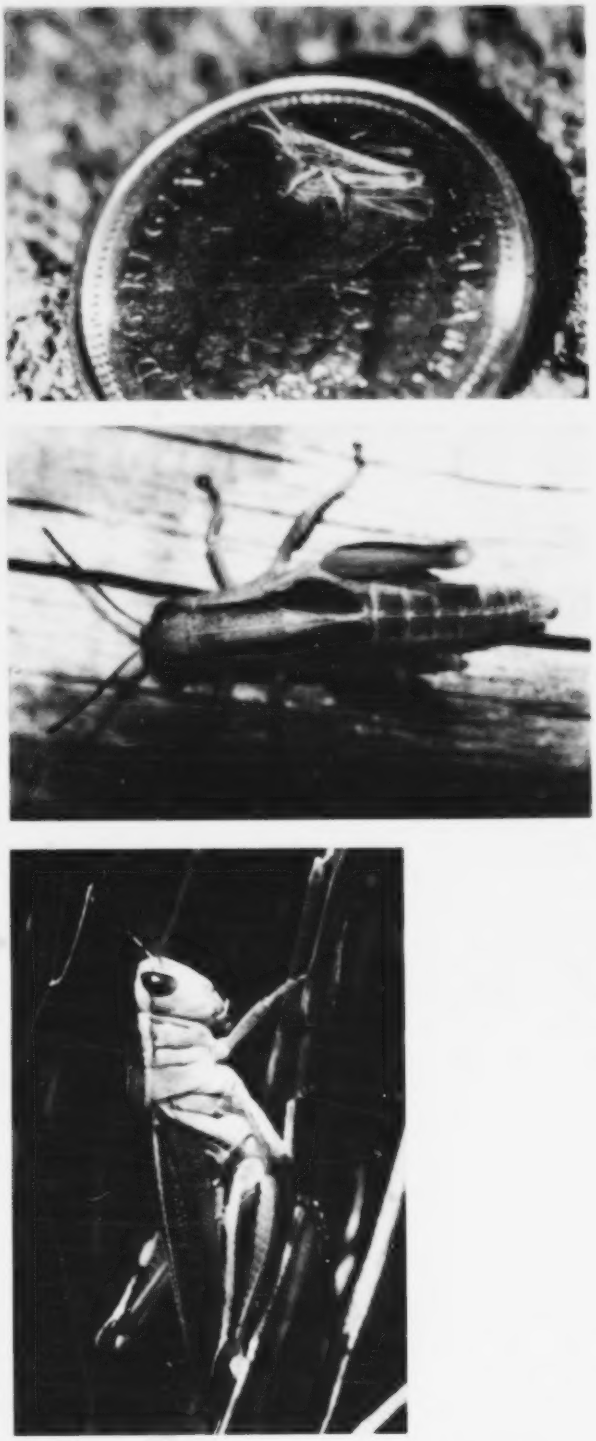
Grasshoppers

Several grasshopper species damage pastures, hay fields and grass and legume seed crops. The most common ones are the migratory grasshopper, *Melanoplus sanguinipes* Fabricius, the two-striped grasshopper, *Melanoplus bivittatus* Say, and the clear-winged grasshopper, *Camnula pellucida* Scudder.



MIGRATORY GRASSHOPPER EGGS, FIVE NYMPHS AND ADULT (FEMALES APPROX 28 MM AND MALES APPROX 20 MM IN BODY LENGTH)

GRASSHOPPER EGGS (5 MM LAID WITHIN PODS DEPOSITED IN THE SOIL)



TWO-STRIPED GRASSHOPPER FIRST INSTAR NYMPH (6 MM IN BODY LENGTH), FIFTH INSTAR NYMPH (10-12 MM IN BODY LENGTH) AND ADULT (26-44 MM IN BODY LENGTH)

CLEAR-WINGED GRASSHOPPER ADULT (FEMALES REACH UP TO 23 MM WHILE MALES CAN REACH 30 MM IN BODY LENGTH)

DAMAGE

Grasshopper species have slightly different host preferences. Clear-winged grasshoppers are more frequently associated with grasses than with forage legumes while migratory grasshoppers have a broad host range that includes most field crops. Grasshoppers usually emerge from egg beds located in pasture and roadside sod, stubble fields and banks of irrigation ditches. Crop injury occurs most frequently in small fields near uncultivated or abandoned land or where fields lie in close proximity to large range areas. Grasshoppers are voracious feeders and devour leaves, buds, flowers and seed pods.

DESCRIPTION AND LIFE HISTORY

The adult migratory grasshopper is mottled greyish yellow to greyish brown. The hind femur has a pink stripe along the lower edge, and the hind tibia is blue or pink. The species is 23 to 34 mm long. Two-striped grasshoppers are generally dark yellowish green with two yellow stripes extending from the head to the tip of the forewings; these grasshoppers are 26 to 40 mm long. Clear-winged grasshoppers are pale yellowish brown to black with two converging pale stripes along the forewings and range in size from 21 to 32 mm long.

Most pest species of grasshoppers in Alberta overwinter in the egg stage. Each adult female can produce about 400 eggs during her reproductive period. The eggs are laid below the soil surface within a protective pod that can contain 20 or more eggs. The eggs hatch in late spring or early summer, depending on the weather. Newly hatched hopper nymphs are wingless and only 4 mm long. Nymphs moult four or five times before they become adults. In late summer and early fall, the adult females lay eggs that remain in the soil until the following spring. Females usually continue to feed and lay eggs until the first frost. There is one generation of grasshoppers per year in Alberta.

ADULT PACKARD'S GRASSHOPPER (UP TO 40 MM IN BODY LENGTH) AND FIFTH INSTAR NYMPH (UP TO 40 MM IN BODY LENGTH)

CONTROL

Weather has a large effect on grasshopper biology and can adversely affect egg laying, survival of eggs within the soil, the rate of development of eggs and nymphs, the spread of natural diseases and the availability of suitable food sources.

Numerous beneficial organisms attack grasshoppers. Egg predators such as blister beetles, ground beetles and crickets seek out and consume eggs while wasp species belonging to the genus *Scelio* are egg parasitoids. Grasshopper nymphs and adults are preyed upon by robber flies and parasitized by sarcophagid and tachinid fly larvae.

A variety of micro-organisms can infest grasshoppers. Warm, humid weather favours epizootics of the fungus *Entomophaga grylii*, characterized by grasshopper corpses left grasping plant stems. *Nosema lucustae* is a microsporidian parasite infecting grasshoppers that consume infected vegetation or even another diseased grasshopper. Nematodes can infest grasshoppers and weaken them.

Early each year, grasshopper forecast maps distributed by prairie provincial governments show the expected extent and severity of grasshopper outbreaks for that growing season. The forecast maps serve as a guide, and careful field monitoring is advised for fields located in areas of high risk.

Cultural control of grasshoppers requires advance planning and can prove invaluable in suppressing grasshopper numbers. Seeding early can enhance the ability of a crop to withstand a grasshopper invasion; plus, it can provide a larger window of opportunity for a producer to respond with insecticide control. Crop rotation is important: seeding into areas heavily infested with grasshoppers should be avoided.

Tillage or chemical fallow before eggs hatch will remove volunteer weeds from summerfallow fields and will reduce available food sources for newly emerging nymphs. Spring tillage to destroy volunteer weeds will starve many newly emerging nymphs before they can relocate to other food sources such as forages.

Trap strips, achieved by cultivating a guard strip around the perimeter, leaving an unworked green strip and again cultivating another guard strip, can serve to concentrate grasshoppers as they enter a field. Grasshoppers are attracted to the green strips, and insecticide can be applied to the area to halt their continued movement into the field. Trap strips require careful monitoring, and additional applications of insecticides may be needed.

Chemical control may be required in areas where outbreaks are forecast. There is no economic threshold for forage seed production. A general guide advises insecticide applications are warranted when at least 13 grasshoppers per square meter are observed in cropped fields and at least 25 grasshoppers per square meter are observed along the roadside. Much lower numbers may warrant insecticide control in high value forage seed crops, particularly when grasshoppers feed directly on maturing seed heads, as in timothy.

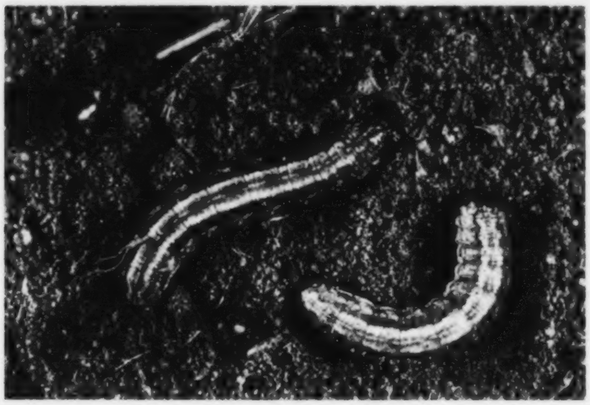
Apply the recommended insecticide as soon as the grasshoppers threaten the crop and always use the recommended rate. If high populations of grasshoppers are predicted, areas where young hoppers are hatching should be sprayed after eggs have hatched but before larger nymphs and adults have moved out.

Cutworms

Cutworms are sporadic pests of legumes and grasses as well as many other plants. Some cutworms are foliage feeders while others damage roots or cut off shoots. In Alberta, there are four common species: two that feed above ground, the army and clover cutworms, and two that feed mainly below ground, the pale western and red-backed cutworms.

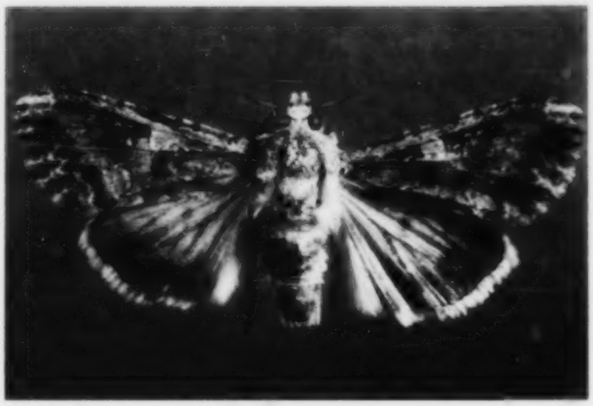
ABOVE-GROUND FEEDERS

The army cutworm, *Euxoa auxilliaris* Grote, is a surface feeder that assumes the 'army' habit of migrating in masses from one area to another. Migrations usually take place from uncultivated land to forage fields, where outbreaks can occur very suddenly. Outbreak years are typically preceded by an extremely dry July followed by a wet autumn. Severe infestations are characterized by complete defoliation of plants. In Alberta, army cutworms also feed on cereals, mustard, flax, sugar beets, various weeds and grasses. Alfalfa can withstand populations of about 50 army cutworms per square meter.

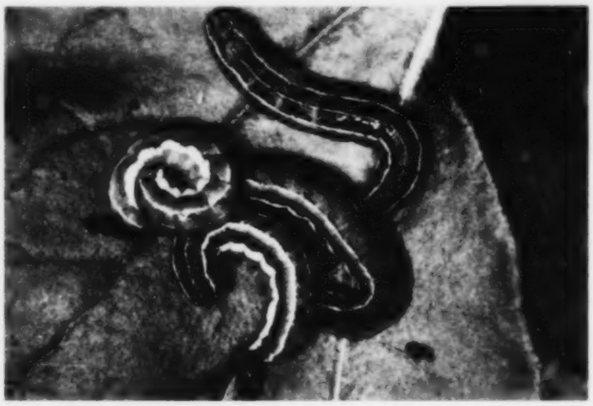


ARMY CUTWORM LARVAE (35-50 MM BODY LENGTH)

The moths of the army cutworm have a wingspan of 35 mm. There is one generation per year. Females lay eggs in soft soil from late July to October. The larvae, which hatch from the eggs in a few days, remain in the soil during the day and feed at night on plant leaves. Larvae are smooth, pale greenish grey to brown with a pale stripe on the back and fine white and brown splotches. The half-grown larvae spend the winter just beneath the soil surface, become active again and feed as the soil warms and pupate in late May and June. Adults emerge in late June.



CLOVER CUTWORM MOTH (WINGSPAN TO 28 MM)



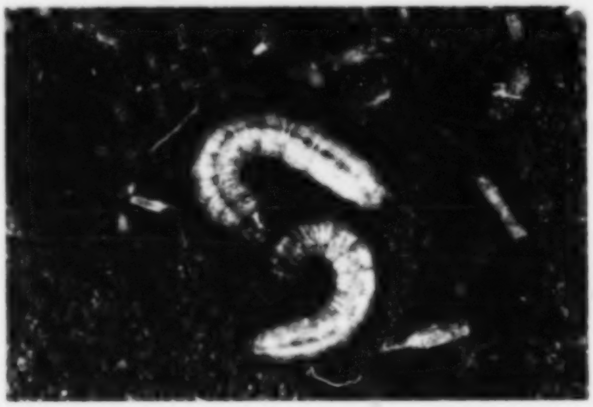
CLOVER CUTWORM LARVAE (UP TO 35 MM IN BODY LENGTH)

The clover cutworm, *Scotogramma trifolii* Hufnagel, feeds above ground on foliage of forages, vegetable crops, sugar beets, rape and weeds. There are normally two generations of clover cutworms per year.

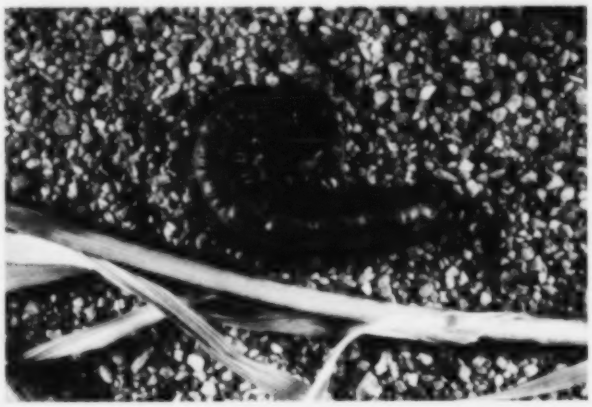
The adults are uniform or mottled ash grey to pale brownish grey moths, with a wing-span of 25 to 28 mm. The eggs, which are white to pale yellow, are laid on the underside of leaves. The newly hatched light green larvae feed on the undersides of leaves. The larvae pass through colour phases of green to brown. Most mature larvae are green or pale brown with a wide yellowish pink stripe along each side. The larvae pupate in the soil. The species overwinters as pupae.

BELOW-GROUND FEEDERS

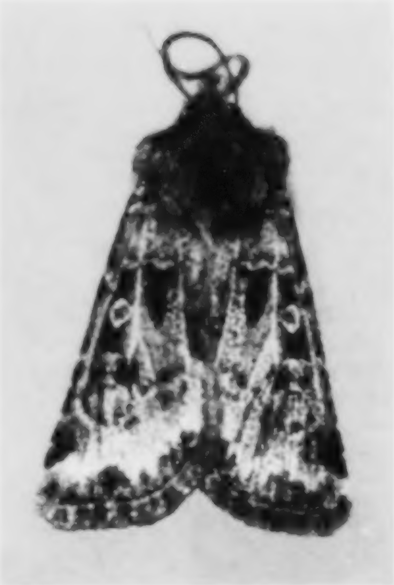
A native species, the pale western cutworm, *Agrotis orthogonia* Morrison, is regarded as a major pest of cultivated crops in Alberta. It has only one generation per year. The larvae feed mainly on plant roots. Primarily a pest of wheat, this cutworm attacks other cereals, forages, mustard, flax, sugar beets and certain weeds. Major damage is by older larvae eating into the stems in June and severing them just below the soil surface. Unlike other species of cutworms, pale western cutworms do not migrate from field to field in search of food.

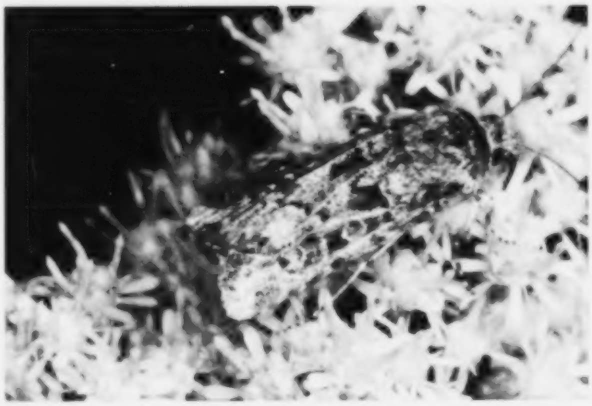


PALE WESTERN CUTWORM LARVAE (TO 32 MM IN BODY LENGTH)

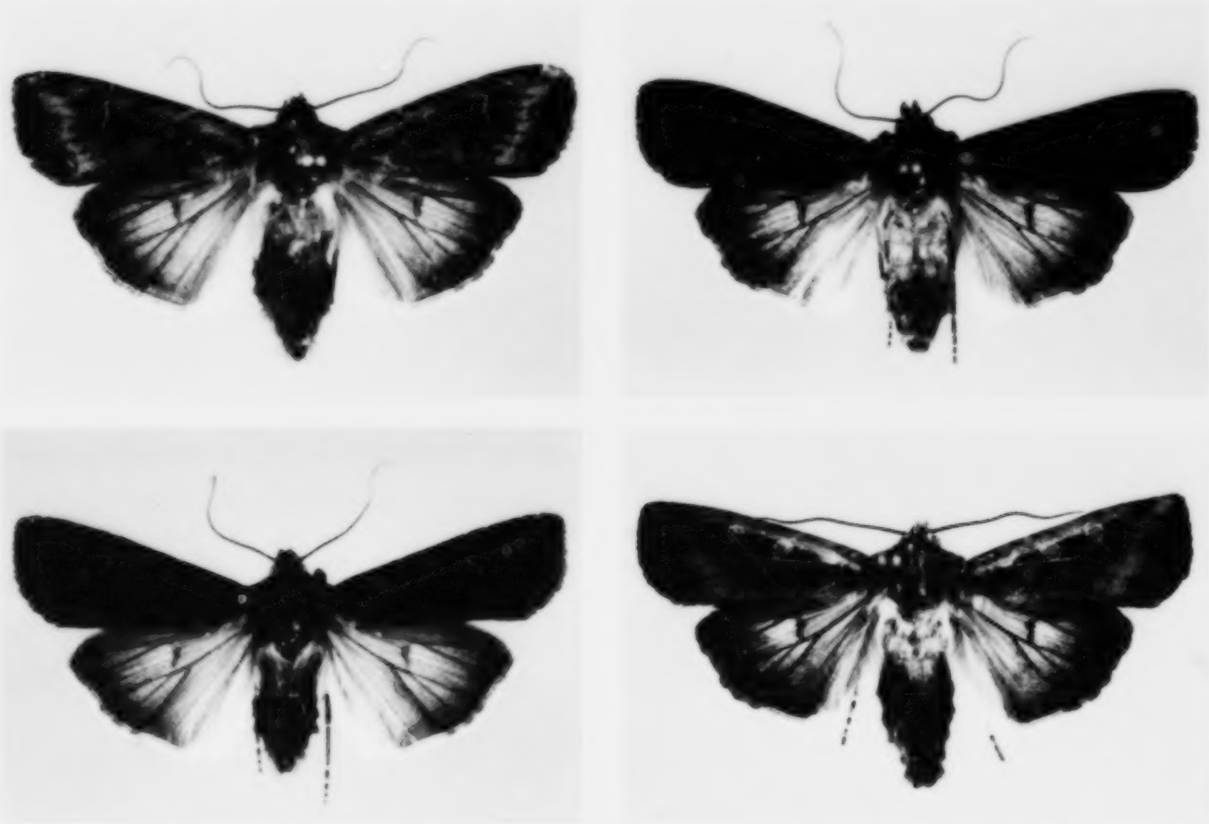


RED-BACKED CUTWORM LARVA (35-40 MM BODY LENGTH)

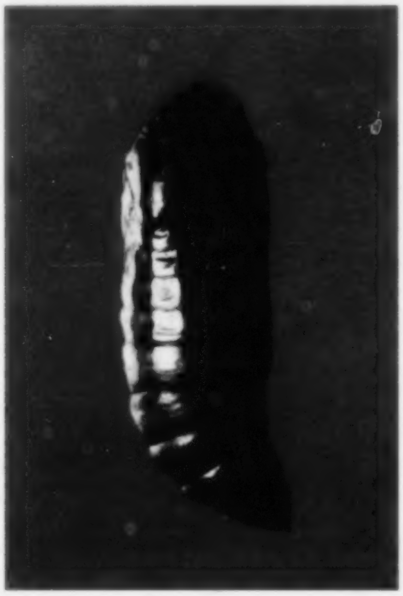




PALE WESTERN CUTWORM ADULT (35 MM WINGSPAN)



FOUR DIFFERENT COLOUR VARIATIONS OF THE ADULT RED-BACKED CUTWORM (WINGSPAN UP TO 50 MM)



TYPICAL CUTWORM PUPA (10-20 MM) REMOVED FROM THE SOIL

The adults, which emerge in August, are greenish grey moths with distinct pale lines on the forewings and a wingspan of 38 mm. There is one generation per year. Eggs are laid singly or in small batches either on or just below the surface of loose soil in August and early September. This species overwinters as eggs that hatch the following spring. Larvae are full grown by late June and are greenish to slate grey with a brown head and can vary in length from 30 to 36 mm. The mature larva forms a chamber or earthen cell of soil particles and pupates inside it.

Frequent rainfall regulates pale western cutworm numbers by saturating the soil and forcing the cutworms to the surface, where they are exposed to predation. During droughts, egg laying is delayed, and emerging larvae may be killed by desiccation.

The red-backed cutworm, *Euxoa ochrogaster* Guenée, has a broad host range, feeding on alfalfa, sweet clover, alsike, sunflowers, cereals, sugar beets, flax, rape, mustard, vegetables, garden flowers and even seedling trees. The young larvae eat holes or notches in the foliage. The presence of larger cutworms is indicated by dead, dried-up plants that have been severed just at or below the soil level.

Adult red-backed cutworms are moths that can vary in colour from tan to brick red, but all have a single white kidney bean shape on the forewing. There is one generation per year. Females lay small, round eggs at night. The eggs are laid at or just below the surface of loose, dry soil in weedy stubble or fallow fields. Red-backed cutworms overwinter as eggs that hatch the following spring. The mature red-backed larva has a reddish coloured back or upper surface and can grow to 38 mm long. By mid-June, the larvae pupate within an earthen cell and become reddish brown pupae. Adults emerge in August and September.

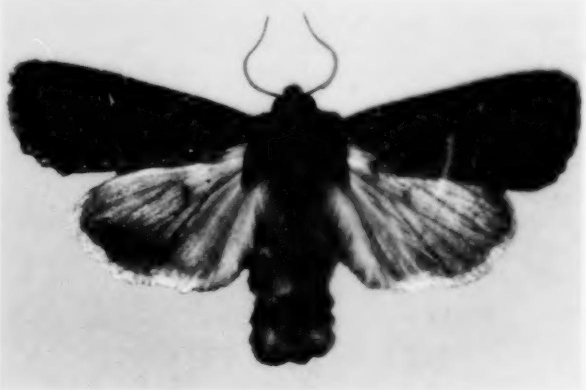
CONTROL

Cutworms are usually maintained at low numbers by parasitoids, predators and pathogenic organisms. Infestations can be reduced or prevented by cultural methods. If fields are cultivated early in spring and left bare of weeds and other growth for at least two weeks, young larvae of the pale western and red-backed cutworms can be starved early after hatching. Fields that have a protective crust throughout August and the first half of September are much less attractive for egg laying as the army, the pale western and the red-backed cutworm prefer to lay their eggs in loose soil.

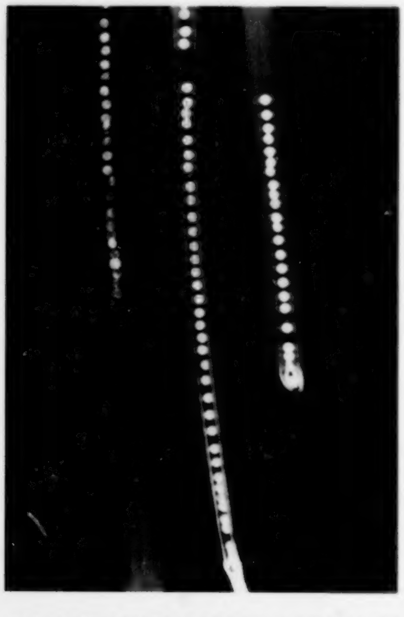
When damage is extensive, control can be obtained by spraying the soil and plants with a recommended insecticide at the recommended rate. Spraying late in the day is advisable for red-backed cutworm control since larvae remain below the soil surface until the evening when they emerge to feed on the foliage.

Glassy Cutworm

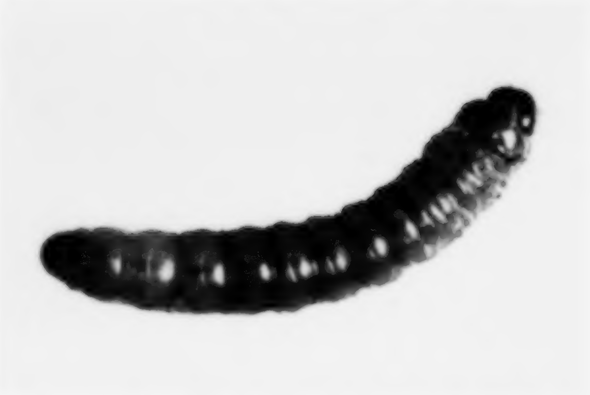
The glassy cutworm, *Apamea devastator* Brace, is an occasional pest of grassy forage, seed and sod production but will also damage corn, cereal or vegetable crops grown on recently broken sod or fields suffering from grassy weeds the previous fall.



GLASSY CUTWORM ADULT (WINGSPAN UP TO 50 MM)



GLASSY CUTWORM EGGS (1.5 MM EACH)

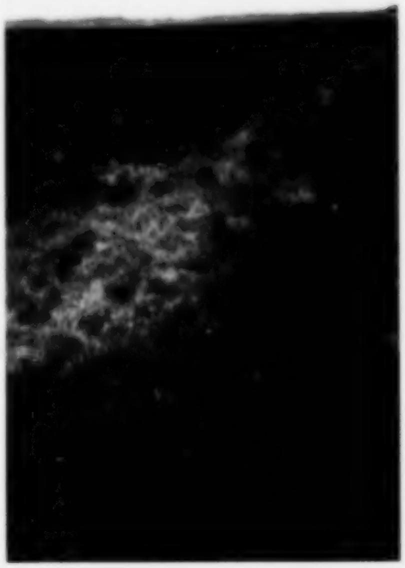


GLASSY CUTWORM LARVA (UP TO 45 MM IN LENGTH) WITH CHARACTERISTIC ENLARGED NECK SHIELD

DAMAGE

The glassy cutworm is associated with grasses and turf but may attack cereals, corn and vegetables, particularly if these crops are planted on newly broken sod or in crops infested with grassy weeds the previous fall. Commonly infested grasses are tall fescue, creeping red fescue, timothy, bluegrass and bromegrasses.

Larvae damage grass stands in the fall and following spring by feeding on stems and the crown either at or below the soil surface. While remaining below the soil surface, a larva clips a leaf or stem and either pulls the leaf down to consume it or continues to clip stems until the entire crown has been detached. Low and even moderate infestations may not cause noticeable damage if growing conditions are favourable and moisture levels are adequate. Drought appears to be an important factor favouring population increases of glassy cutworm. The severe outbreak in the Peace River Region in 2000 followed two years of drought.



GLASSY CUTWORM DAMAGE VISIBLE AS BROWN PATCHES IN CREEPING RED FESCUE WHERE STEMS HAVE BEEN CLIPPED AT OR BELOW THE SOIL LEVEL

DESCRIPTION AND LIFE HISTORY

The glassy cutworm is a glossy, semi-translucent greenish white or grey larva lacking body markings, but having a prominent reddish brown head and neck shield. Mature larvae are 35 to 40 mm in length and pupate in the soil near the host plant. The spindle-shaped pupa, within which the transformation to the adult moth occurs, is reddish brown and approximately 20 mm in length. Adults are nondescript, medium-sized (35 - 40 mm wing span) grey miller moths with a scattering of dark markings on the forewings. They are in flight from July to early September.

Adults mate during the flight period although the majority of eggs are laid in batches on leaves of host plants during August. The eggs, which are 0.55 mm in diameter, are usually laid on the upper surface of a grass leaf, near the base. Newly laid eggs are glistening white, but progressively darken until they hatch after about one week.

After egg hatch, the larvae immediately begin to feed on the host plant and will usually be about half grown by freeze-up. The cutworm overwinters as a partly grown larva and resumes feeding again early the next spring as soon as new green growth appears. The larvae feed underground, or in the case of bunch grasses, within the crown, and rarely come to the surface. They pupate in the soil by the end of June. There is one generation per year.

CONTROL

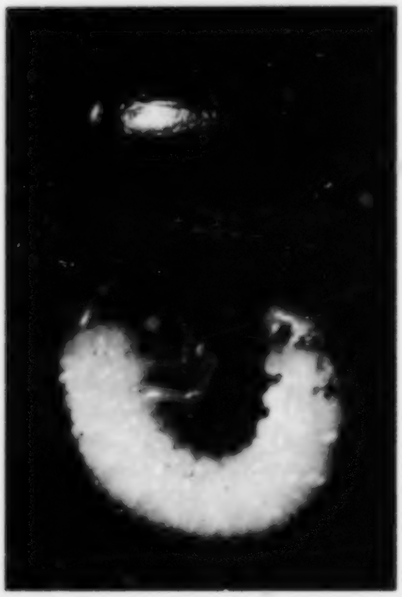
There is no established economic threshold for glassy cutworms in crops or pastures. Newly broken land and summerfallow with grassy weeds should be well cultivated during August to prevent new growth suitable for egg laying. Fields at risk should be monitored for evidence of browning-off or unusually poor growth during both the fall and early the next spring. Damaged or sickly plants should be dug up, and the roots and surrounding soil searched for the presence of cutworms.

Insecticides, if required, should be applied with as high a water volume as is feasible (around 200 L/ha) in order for active ingredients to penetrate the crown and root areas where larvae reside. The larvae rarely come above the soil surface, so they do not come in contact with most foliar-applied insecticide products. If larvae are close to pupation (i.e. larvae are >35 mm long), insecticide applications are not recommended since feeding damage will end soon with the development to the non-feeding pupal stage.

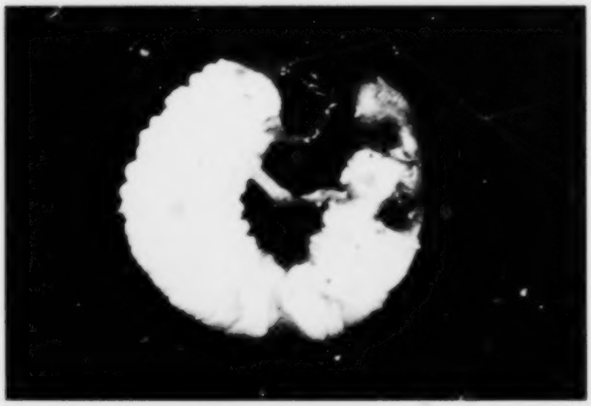
Numerous beneficial insects, including both predatory ground beetles and parasitic wasps and flies, were observed in the outbreak populations of glassy cutworm in the Peace River Region in 2000. In some fields, 50 per cent of cutworms were parasitized. These natural enemies are often effective in suppressing cutworm populations below damaging levels. Therefore, unnecessary use of insecticides should be avoided.

White Grubs

White grubs are the larvae of June beetles. The common species are mainly in the genera *Phyllophaga* and *Polyphylla*. Occasionally, these insects are of serious economic importance to forages.



THE JUNE BEETLE (TOP) IS THE ADULT FORM OF THE WHITE GRUB (BOTTOM)



JUNE BEETLE LARVA REMOVED FROM SOIL

DAMAGE

The larvae feed on the roots of many plants, especially grasses, and are most plentiful on light and acid soils. Commonly occurring in pastures, meadows, sod and lawn, white grub larvae can be a serious problem on grass crops, especially timothy, seeded into newly broken grassland. Infestations of more than 24 white grubs per square meter are potentially of economic significance. Legumes are seldom damaged.

DESCRIPTION AND LIFE HISTORY

The full grown, greyish white larvae are over 25 mm long, have brown head capsules, three pairs of prominent legs and are always bent in a C-shape. They have a double row of minute hairs on the underside of the last body segment, which distinguishes them from other soil-dwelling larvae that are mainly decomposers.

Numerous species of white grubs can be crop pests, the most common of which have a three-year life cycle. Typically, in the spring of the first year, the large brown or striped June beetles fly in the evening or night, congregating and feeding on tree foliage. Female beetles lay pearly white eggs in small cavities 2.5 to 10 cm (1 - 4 in.) deep in field soil in May and June. Young larvae feed mainly on decayed vegetation and overwinter below the frost line. In the second season, larvae attack crops, feeding on and shredding roots so that grass plants become weak and detached. Consequences of such feeding include crop loss, wind erosion and heavy weed infestations. In the third summer, the larvae pupate in the soil, and the emerging adults remain inactive below the soil surface where they overwinter until the next May or June.

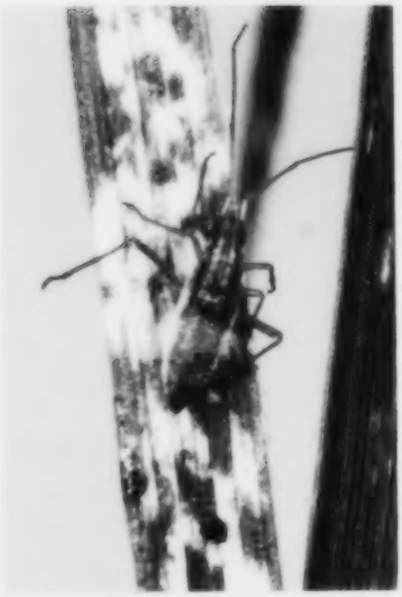
CONTROL

White grubs are attacked by a wide range of predators including predatory beetles, wasps, mites, spiders, nematodes, fungi, birds, moles and skunks. Removal of grass thatch and soil cultivation will expose grubs to predators and detrimental weather conditions. Active larvae in the soil can be controlled by rototillering or ploughing. Tilling an infested area the year before seeding a grass crop and letting it remain fallow for the summer, if possible, will decrease white grub numbers.

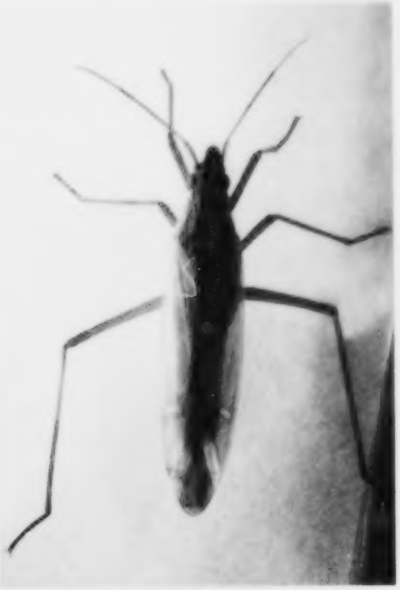
Planting grass cultivars that contain endophytic fungi will help repel white grubs. Such fungi, specific to some fescues and ryegrasses, help the plants cope with a variety of environmental stresses, including drought and insect attack. If pesticides are used, ample water should be applied to allow penetration of the insecticide deeply into the soil.

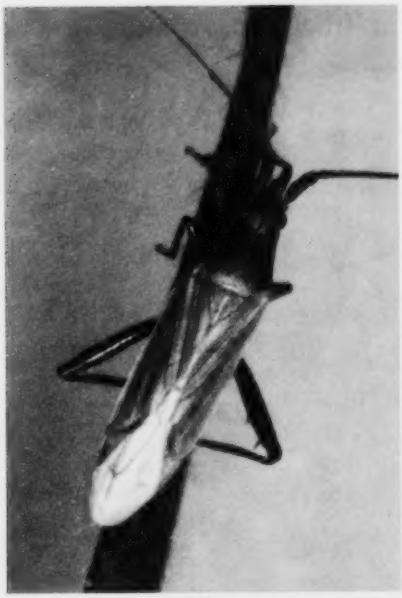
Grass Plant Bugs

In Alberta, there are several species of plant bugs that damage forage grasses. Although they belong to the same family, Miridae, plant bugs injuring grass are different than those that injure alfalfa. Grass-feeding plant bugs include black coloured species in the genera *Capsus*, *Labops* and *Irbisia* and larger green or tan coloured plant bugs in the genera *Stenodema*, *Trigonotylus* and *Leptoterna*.

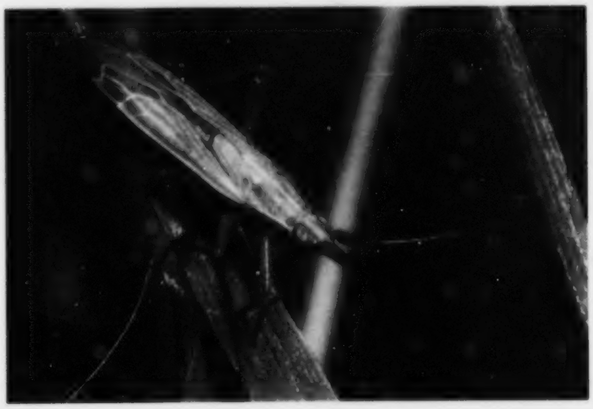


GREEN GRASS PLANT BUG NYMPH (1-6 MM IN BODY LENGTH) AND FEEDING DAMAGE ON LEAF

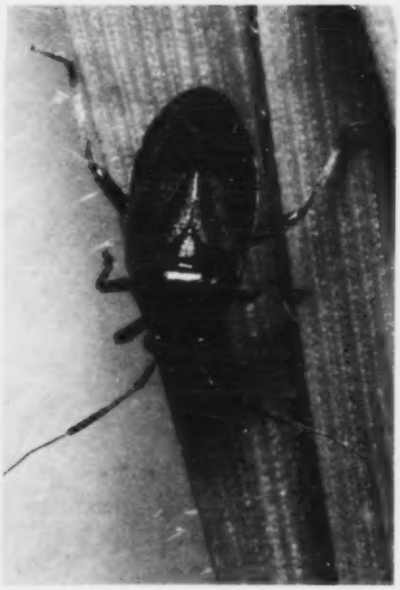




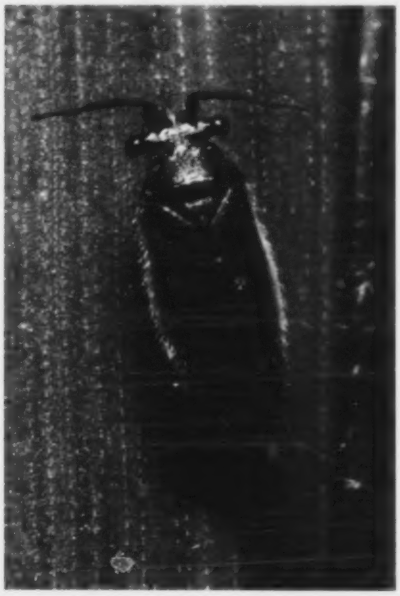
GREEN GRASS PLANT BUG ADULTS (5-7 MM IN BODY LENGTH)



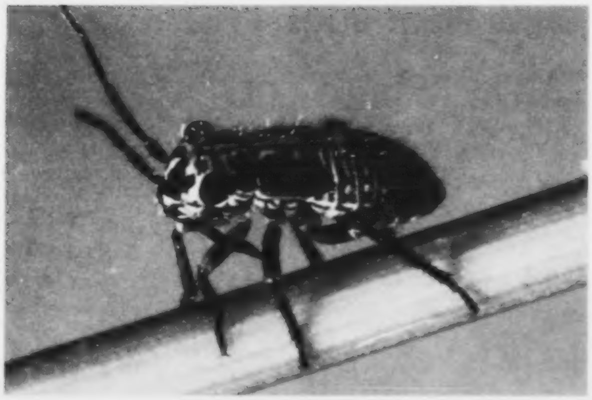
STENODEMA PLANT BUG ADULT (7 MM) RESTING ON GRASS



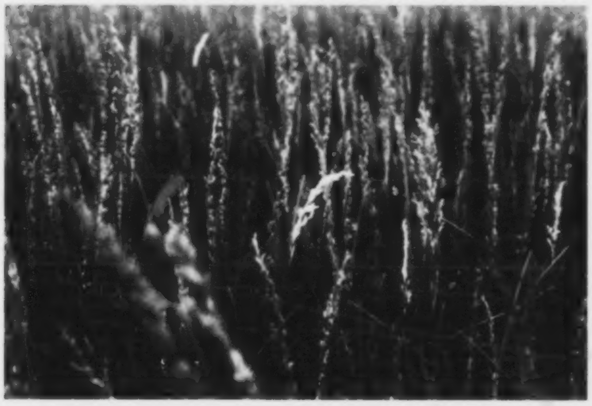
CAPSUS ADULT (4 MM IN BODY LENGTH)



LABOPS ADULT (6-8 MM IN BODY LENGTH)

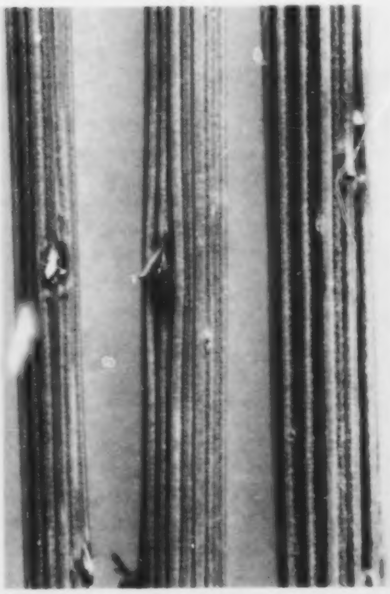


LABOPS NYMPH (1-6 MM IN BODY LENGTH)



SILVERTOP OR STERILE SEED HEADS IN INTERMEDIATE WHEATGRASS

Grass Plant Bugs



FEEDING PUNCTURES IN GRASS CAUSED BY GRASS PLANT BUGS

DAMAGE

Grass plant bugs have piercing-sucking mouthparts that they use to extract plant sap. Although heavy feeding by plant bugs on immature grasses can decrease forage quality and stunt plant growth, the bugs are not considered a major pest of grass forage production. Feeding on stems before or at the boot stage can cause sterility and bleaching of seed heads, a condition known as silvertop.

DESCRIPTION AND LIFE HISTORY

The life histories of these plant bugs are similar to those of the plant bugs that commonly infest alfalfa. Grass plant bugs overwinter as adults or eggs in litter or debris in and near grass fields. Females lay eggs inside grass stems or in crowns. The eggs hatch into nymphs that complete their development in approximately four weeks.

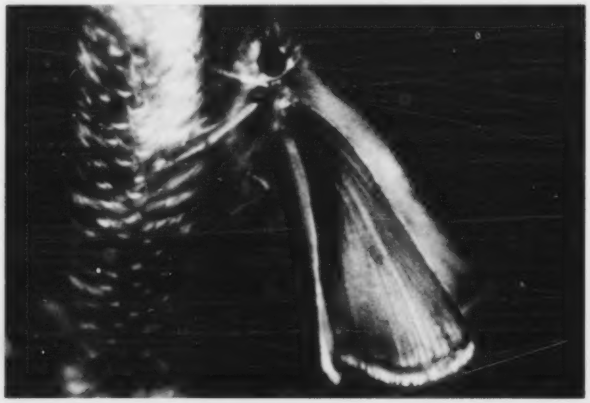
CONTROL

Economic thresholds for insects that cause silvertop in grass seed fields depend on seed prices, which vary widely. Once silvertop at economic levels is seen in a field, nothing can be done to regain seed yield in the current year. In general, grass fields exhibiting 10 per cent or more silvertop should have remedial action taken by the following spring.

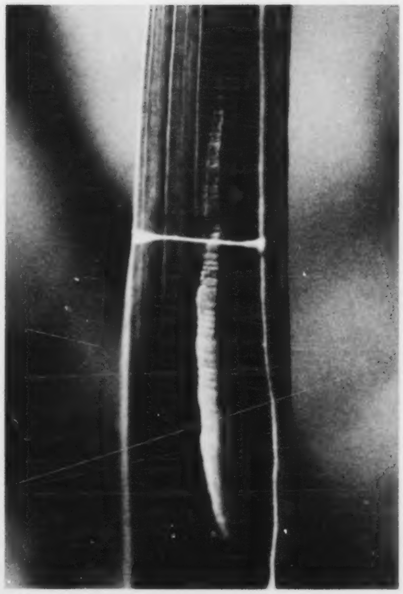
In regions where burning is permitted, a post-harvest burn or spring burn implemented before new growth occurs will destroy plant bug eggs and adults. Burning creeping red fescue in the Peace River region is not recommended because the practice can affect subsequent seed yields although burning before rejuvenation can be done. Mowing to a height of 3 cm (1 1/4 in.) and removal of straw after harvest also decrease silvertop incidence in stands. If an insecticide is used for control of grass plant bugs, it should be applied before the boot stage of the grass.

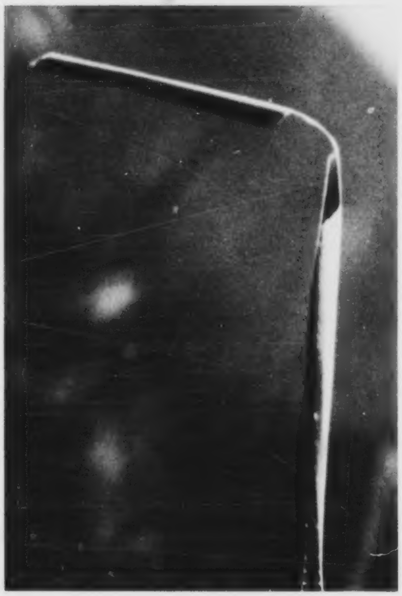
European Skipper

The European skipper is a colourful butterfly, the larva of which is a pest of timothy grown for hay and seed in eastern Canada. Other host plants include perennial ryegrass, meadow fescue, orchardgrass and quackgrass. To date, the skipper has spread west to Saskatchewan.



EUROPEAN SKIPPER ADULT (19-26 MM) ON TIMOTHY SEED HEAD





LEAF TYING BY A EUROPEAN SKIPPER LARVA (UP TO 11 MM), CAUSING TIMOTHY LEAF TO ROLL UP, AND FEEDING ON LEAF ABOVE ROLL, CAUSING LEAF CLIPPING

European Skipper

DAMAGE

Larvae, the most damaging of which are the fourth and fifth instars, irregularly notch leaf margins and in heavy infestations, can completely defoliate a timothy field. If defoliation is extensive, the larvae will also feed on seed heads. Legume flowers are the preferred nectar sources for the butterflies. Therefore, mixing legumes and timothy in hay fields can worsen the problem because such a practice provides an abundance of food and egg-laying sites in the same field.

DESCRIPTION AND LIFE HISTORY

Adult skippers are bright orange butterflies with narrow, dark wing borders and thin black lines along main veins. Their wingspan is about 25 mm. Larvae are greenish, with two white stripes extending from their heads down the back. Fully grown larvae are about 25 mm.

The insect overwinters in timothy and other grass fields as first instar larvae in the shell of the eggs. Larvae emerge from the eggs in early May, crawl up growing grass blades and form leaf tubes by tying the edges of the leaves together with silk. In heavy infestations, older larvae do not make leaf tubes but feed in the open. They develop through five instars and pupate on the underside of leaves or on leaf debris on the ground.

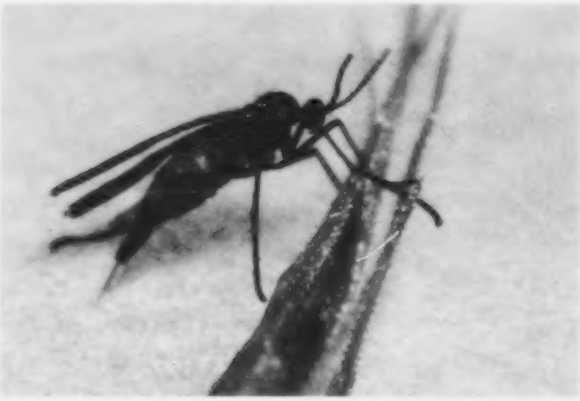
Adult butterflies emerge in early July and mate, and females lay vertical rows of eggs on the inside of grass leaf sheaths. These eggs develop into larvae by late July, but these remain in the egg shell until the following spring.

CONTROL

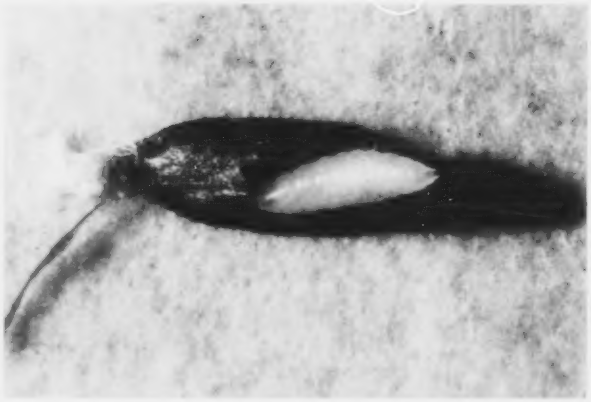
Because eggs can survive in baled hay, care should be taken when transporting hay from infested areas. Eggs can also survive in seed screenings, so all such screenings of timothy seed from infested areas should be destroyed. Greater than 6 skipper larvae per 30 x 30 cm (12 x 12 in.) area of grass may warrant control. If larval numbers reach economic levels, an application of insecticides containing *Bacillus thuringiensis* Berliner can control them. Cut grass should be removed as soon as possible after baling to reduce the number of eggs laid. Skipper numbers can also be reduced in pastures containing timothy by heavy grazing of short duration.

Bromegrass Seed Midge

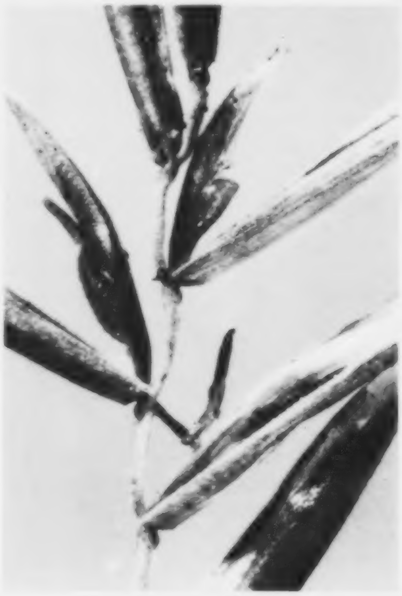
Bromegrass seed midge, *Contarinia bromicola* Marikovski & Agafanova, is a pest in Alberta bromegrass seed fields. It does not attack other grass species.



BROMEGRASS SEED MIDGE ADULT (3 MM) ON A SEED HEAD

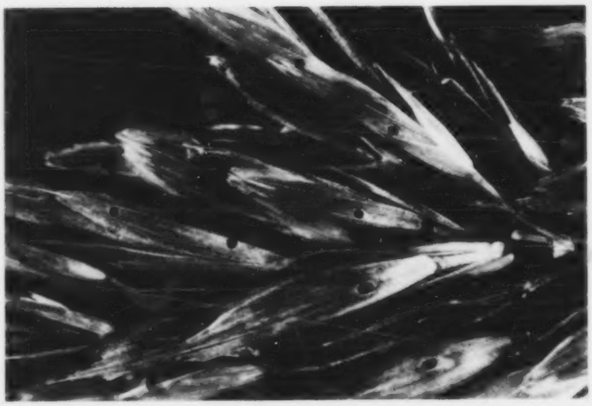


CLOSE-UP OF BROMEGRASS SEED MIDGE LARVA (2 MM)

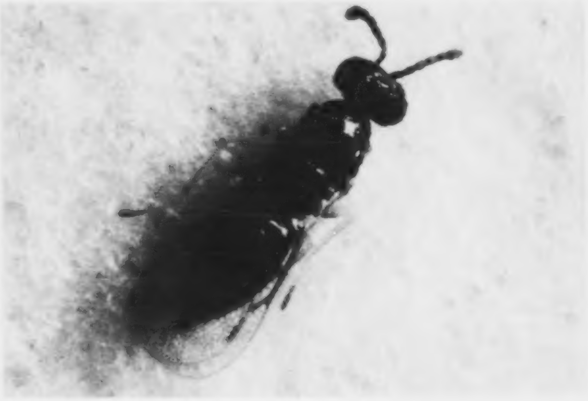


FEEDING DAMAGE ON A BROMEGRASS SEED HEAD RESULTING IN EMPTY PANICLES

Bromegrass Seed Midge



BROMEGRASS PANICLES WITH PARASITOID WASP EMERGENCE HOLES



BROMEGRASS SEED MIDGE PARASITIC WASP, *Aprostocetus* sp.

DAMAGE

Bromegrass seed midge larvae cause seed losses by feeding on developing bromegrass seeds, destroying florets and increasing shattering losses in the process. In some years, seed losses of greater than 50 per cent have occurred.

DESCRIPTION AND LIFE HISTORY

Midge adults are small flies the size and appearance of mosquitoes. They are similar in appearance (although not in colour) to the orange wheat blossom midge. The maggot-like golden yellow larvae are found in the bromegrass floret. The midge overwinters as a larva or pupa in bromegrass seed hulls on the soil surface. Larvae pupate in the spring, and adults emerge at about the time the grass is heading out.

There are usually two peaks in adult emergence, suggesting that there are two generations per year. Female midges lay their eggs in developing flower heads, and when these hatch, the larvae feed on the flower ovaries. Later egg laying occurs on older flowers, and the emerging larvae feed on young seeds. The larvae pupate at the tips of seed hulls that drop to the ground at harvest. Damage is frequently more severe in older than in younger stands, in wet years or in areas of high humidity.

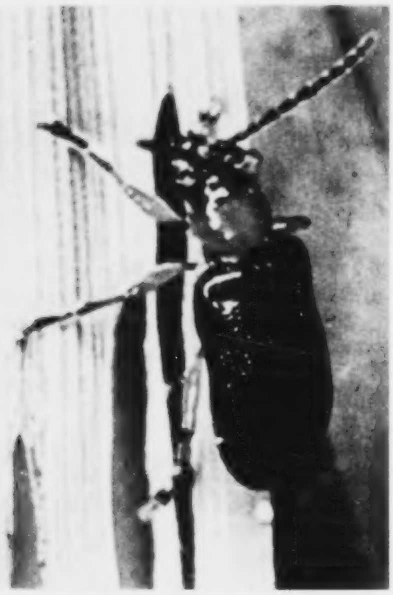
CONTROL

Midge damage to bromegrass can sometimes be detected by the presence of tiny holes in the seed heads. These are the exit holes of a wasp parasite of the midge. The presence of wasp exit holes, a measure of the infestation of bromegrass by the midge, underestimates the amount of infestation because not all the midges will have been parasitized.

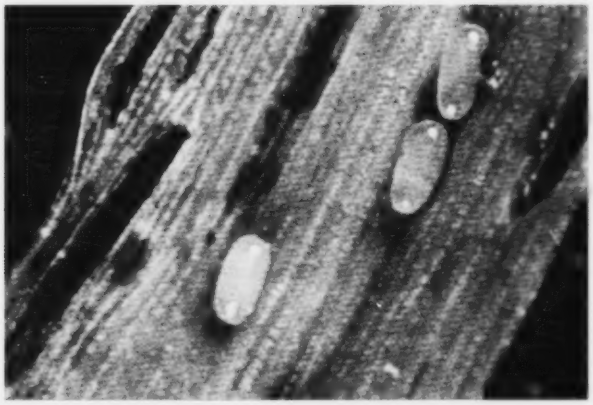
Post-harvest or spring burning of grass fields provides some midge control. Destroying or early mowing of patches of volunteer bromegrass will reduce seed midge numbers. Economic thresholds for bromegrass seed midge are unknown. Treating with an insecticide just before or at heading can reduce midge numbers but will also kill its parasite. Timing of the insecticide application is essential for effective control, but damage levels may not justify the costs of treatment. Meadow bromegrass appears to be less susceptible to the midge than smooth bromegrass.

Cereal Leaf Beetle

The cereal leaf beetle, *Oulema melanopus* (L.), was found near Lethbridge and Taber in September of 2005. This was the first occurrence of this insect in the prairie provinces. A serious pest of cereal crops, cereal leaf beetle can also be a destructive pest of grasses, including sorghum and Sudan grass (*Sorghum* spp.), millet (*Panicum* spp.), blue grass (*Poa* spp.), bromegrasses (*Bromus* spp.), canary grass (*Phalaris* spp.), fescues (*Festuca* spp.), orchardgrass (*Dactylis* spp.), redtop (*Agrostis* spp.), ryegrass (*Lolium* spp.), timothy (*Phleum* spp.), wheatgrasses (*Agropyron* spp.) and wild rye (*Elymus* spp.).



CEREAL LEAF BEETLE ADULT (7 MM) FEEDING ON GRASS



EGGS (EACH 1 MM) LAID SINGLY ON GRASS LEAF

LARVA (UP TO 5 MM IN BODY LENGTH) FEEDING ON GRASS BLADE

CHARACTERISTIC STRIPE-LIKE FEEDING DAMAGE CAUSED BY CEREAL LEAF BEETLE ADULTS AND LARVAE

A phytosanitary certificate may be necessary for the movement of straw or hay containing the above grass species out of infested districts. Producers should check current regulations regarding cereal leaf bettle to determine if a phytosanitary certificate is required.

DAMAGE

Both adults and larvae feed on cereals and grasses, although larvae cause the most damage. Adults chew long strips of tissue along the veins of grass blades, leaving narrow slits. Larvae feed on the mesophyll cells of a leaf, leaving only the transparent lower leaf surface. Under heavy feeding, the crop takes on a whitish appearance. Damage may be localized within a field.

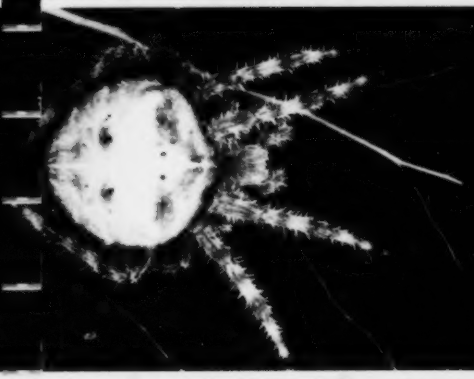
DESCRIPTION AND LIFE HISTORY

The adult cereal leaf beetle is about 6 mm long and has a metallic, bluish black head and wings, with reddish legs and a rust coloured thorax. The yellowish brown elliptical eggs are laid on the upper leaf surface in between and parallel to the leaf veins. Larvae resemble small Colorado potato beetle larvae in shape. Their body colour is yellowish; however, the body is usually covered by a blob of mucus and feces, so that it appears wet and black. This liquid wipes off readily and can stain the shoes and pant legs of someone walking in an infested field.

Beetles overwinter as adults in plant residue on the soil surface and sheltered areas close to previously infested crops. Adults, which become active when temperatures exceed 13° C, feed on young cereals, mate and lay eggs on host plants. Small larvae eat a very small amount, but later instar larvae have a voracious appetite. Pupation occurs in an earthen cell in the soil, and adult beetles emerge to feed on late season grasses before seeking overwintering sites. There is one generation per year.

CONTROL

The United States has introduced several exotic parasitoids that have some effect in keeping the cereal leaf beetle in check. It is not known if these parasitoids will become established in Canada. Some native biological control agents, especially ladybird beetles, appear to eat cereal leaf beetle eggs and young larvae in early summer. There is evidence that heavily seeded wheat fields are less subject to develop high cereal leaf beetle populations as adults prefer late planted and thinly sown fields. No economic thresholds are available for cereal leaf beetle in forage grasses, but one nominal threshold for small grains is 25 eggs and/or small larvae per 100 tillers.



NATURAL ENEMIES OF PEST INSECTS

Natural Enemies of Pest Insects

Natural enemies are those organisms that prey on, parasitize or infect pest species. The natural enemies play an important and usually unrecognized role in suppressing populations of pests thereby reducing the frequency and severity of outbreaks. To enhance the ability of these organisms to provide natural control, it is important to be able to identify them and to know what measures should be taken to conserve them.

Natural enemies can be classed into three categories: predators, parasitoids and pathogens. Predators actively pursue and capture their prey. Most consume the victim immediately, but female predatory wasps also use the captured prey to provision their young. Many species are predatory in both the larval and adult stage whereas others are predatory only as larvae. Most predator species are more habitat specific than prey specific and have a suppressing effect on pests in general. However, some have a definite prey preference, such as ladybird beetles that feed primarily on aphids. Predators other than insects are spiders, predatory mites, daddy-long-leg spiders and some vertebrates.

Parasitoids are insects that lay their eggs on, or into, an insect of another species, and the ensuing larva feeds on the tissues of the victim, eventually killing it. They tend to be host specific, attacking only one species or a number of related species. Because parasitoids are host specific, they depend on the availability of a suitable host for their survival.

Pathogens are micro-organisms that cause disease by infecting the tissues of the host. They include fungi, protozoans, bacteria and viruses. Pathogens usually become more common towards the end of a pest insect outbreak and are frequently responsible for terminating it.

Natural enemies are most effective in a stable environment such as provided by a perennial forage crop, where they are an important component of integrated pest management.

When insect populations are undisturbed by man, then beneficial insects, disease organisms and unfavourable weather often destroy 50 to 90 per cent of a potential pest population. When pest species are controlled with a pesticide, many beneficial predators and parasitoids present will also be killed. Using pesticides only when necessary, using spot applications when feasible and, if possible, avoiding the use of broad spectrum insecticides will aid in conserving beneficials.

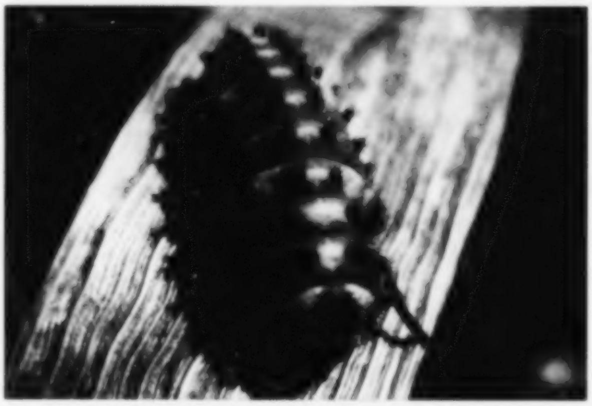
Growers should learn to recognize the major natural enemies associated with forage production. Some of the more important ones found in Alberta are described below.

Predators

LADYBIRD BEETLES

Ladybird beetles, also known as lady bugs, are one of the most readily recognized beneficial insects. The adults are 4 to 7 mm in length, have an oval, rounded shape, and most species are red, orange or yellow with various patterns of black spots. The larvae are black or bluish with spots and rows of tubercles on the dorsal side. They are elongate, tapered towards the rear end and look like miniature alligators. When full grown, the larva fastens itself by its "tail" to any convenient vertical surface, and the skin splits down the back to reveal the orange and black tear-drop shaped pupa.

LADYBIRD ADULT (7-8 MM IN BODY LENGTH) RESTING ON WHEAT HEAD



LADYBIRD LARVA (6 MM IN BODY LENGTH) CONSUMING PEA APHID ADULT

LADYBIRD PUPA (6 MM) ATTACHED TO WHEAT HEAD

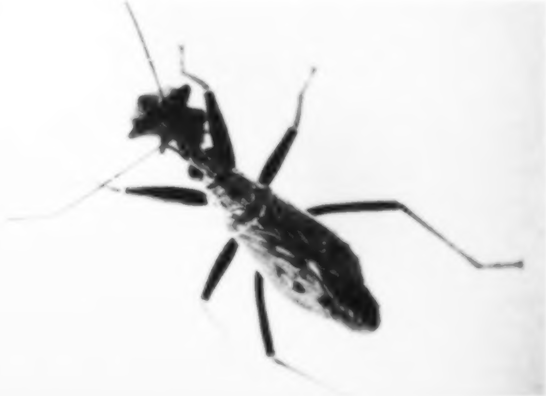
More than a dozen species of ladybird beetles are found in Alberta. The most common are in the genera *Coccinella*, *Hippodamia* and *Adalia*. Ladybird beetles will eat many kinds of small insects and mites, but most species have a preference for aphids. Each adult or large larva can consume up to 25 aphids per day depending on the size of the aphids. They play an important role in keeping populations of aphids below injurious levels.

Ladybird beetles overwinter as adults, and most species spend the winter locally in protected sites under dead leaves or crop residues. However, a few species migrate during the fall to overwintering aggregation sites in the foothills and mountains. In spring, the adults disperse widely before starting to lay eggs. Each female can lay several hundred eggs during a lifetime of several months. Because of the adults' tendency to disperse, there seems to be little value in collecting adult beetles at hibernation sites for release in forage fields.

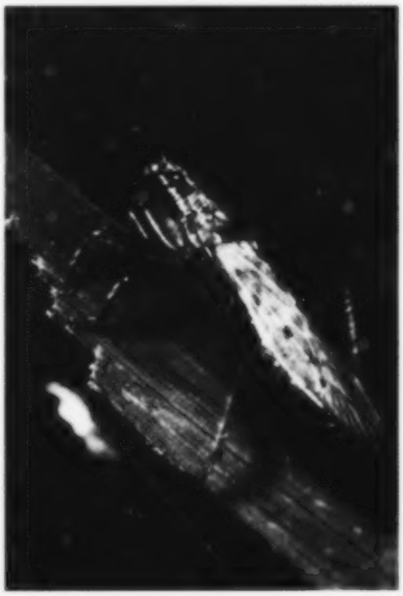
DAMSEL BUGS

Damsel bugs are slender true bugs (Hemiptera) with grasping front legs. The adults are greyish brown and about 8 mm in length. Both the nymphs and adults are general predators on a wide variety of insects. They are an important predator of pea aphids and alfalfa weevil larvae and probably the most important predator of lygus bugs.

The adults overwinter in the vicinity of forage fields or other perennial habitat. Although they can be readily found in fields in early spring and summer, they do not become numerous until late July and throughout the fall.



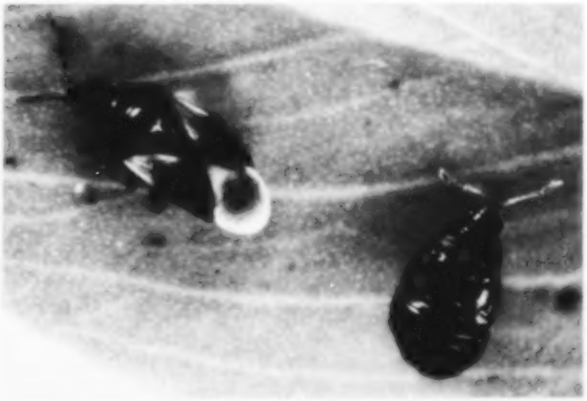
DAMSEL BUG ADULT (8-10 MM) FEEDING ON LYGUS BUG NYMPH



DAMSEL BUG ADULT (8-10 MM) RESTING ON ALFALFA

PIRATE BUGS

Pirate bugs are oval, flat, black and white insects less than 4 mm in size. A common species, the minute pirate bug, *Orius tristicolor* White, is only 2 mm long and is one of the smallest predatory insects occurring in forage crops. Nymphs resemble adults but are yellow to reddish orange. The eggs are inserted into the stems and petioles of plants such as alfalfa. Newly hatched nymphs suck plant juices, but later instars are carnivorous.



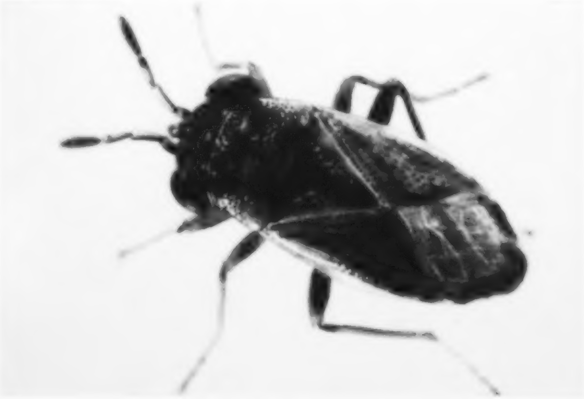
MINUTE PIRATE BUG ADULT (LEFT 2-3 MM) AND NYMPH (2 MM)

Pirate bugs overwinter as adults on the ground in sheltered sites within or near fields. They often become common in alfalfa during July and August, especially if the crop is blooming. Because of their small size, their prey is limited mostly to other small insects and mites, but the eggs and early stage immatures of larger insects are also avidly consumed. The adults will bite humans if they come in contact with bare skin, but the bite is of no consequence.

BIG-EYED BUGS

Big-eyed bugs are dark greyish brown and are sometimes confused with lygus bugs or false chinch bugs because their bodies are similarly shaped. However, big-eyed bugs can be distinguished by their wider head and large bulbous eyes, which are present in both the adult and nymphal stages.

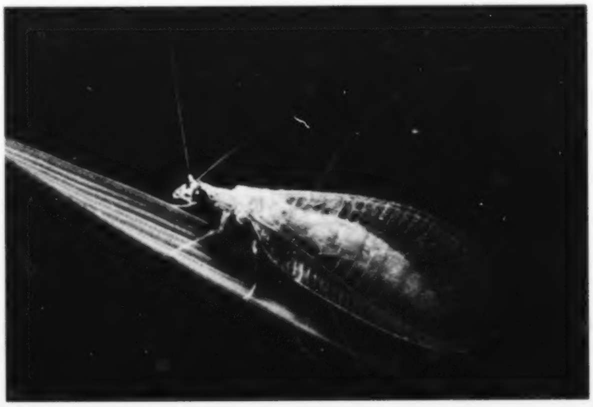
Both adults and nymphs feed on many small insects and mites and are important predators of aphids, plant bugs and leafhoppers, but they prefer mites, aphids and insect eggs rather than active prey.



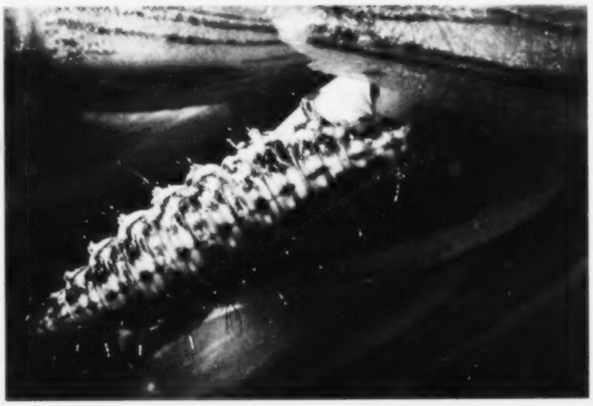
BIG-EYED BUG ADULT (4 MM IN BODY LENGTH)

GREEN LACEWINGS

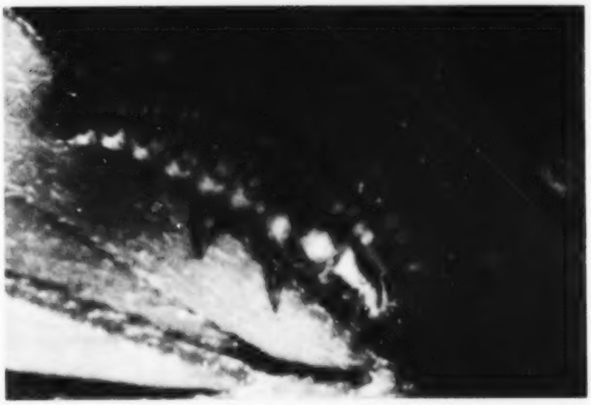
Adult green lacewings are green with delicate, net-veined wings that are folded over the back when at rest. They are weak fliers with a wingspread of about 30 mm. Because of an attraction to lights at night, they are often observed near the doorways of houses. They are sometimes called golden-eye flies because of the metallic gold or copper colour of their eyes. Other species are called stink flies because they give off an unpleasant odor when handled. The adults of most species feed on nectar, pollen or honeydew produced by aphids, but some are predacious.



LACEWING ADULT



LACEWING LARVA (5-6 MM IN BODY LENGTH) FEEDING ON APHID



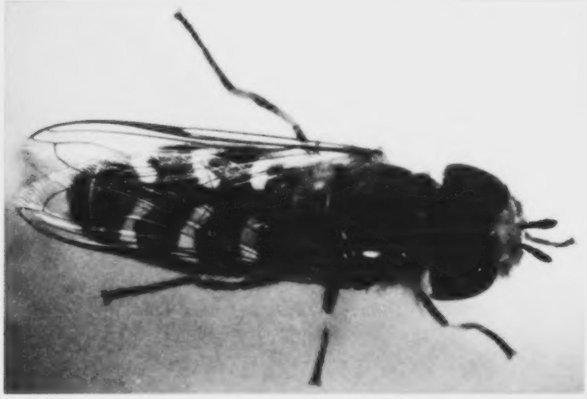
LACEWING LARVA (5-6 MM IN BODY LENGTH) WAITING FOR PREY

The eggs are laid singly on the tips of slender stalks about 7 mm long on the underside of leaves. The larvae, known as aphid lions, are voracious predators that feed on a wide variety of prey. They are somewhat similar in shape to ladybird beetle larvae but are flatter, smaller, mottled brown, light yellow and white.

Instead of consuming their hosts entirely, as the ladybird beetle larvae do, lacewing larvae pierce their victims with their large hollow, sickle-shaped jaws and suck out the body fluids. They are an important beneficial predator in forage fields. When fully grown, the larvae spin oval or spherical, closely woven silken cocoons that are usually attached to the underside of leaves.

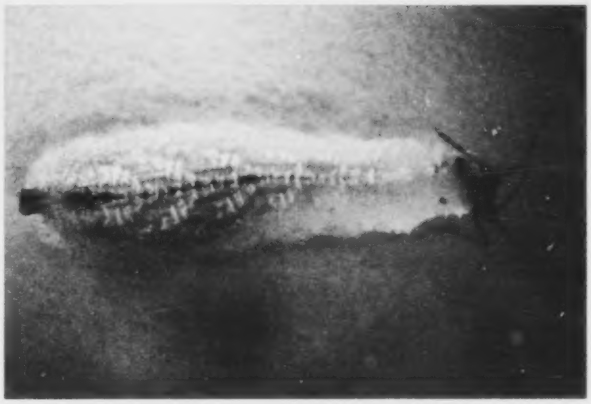
HOVER FLIES

Many species of syrphid or hover flies are in Alberta. The adults have black and white or black and yellow markings on the abdomen and resemble small bees or wasps. They are most active during the day, often hovering over flowers then darting away suddenly for a short distance before resuming their hovering. The adults feed on honeydew, nectar and pollen. They are important pollinators of some plants, but their value as pollinators of forage crops appears to be minimal.



SYRPHID FLY ADULT (7 MM IN BODY LENGTH)

SYRPHID FLY LARVA (GREEN WORM ON LEAF AT FAR LEFT) PREYING ON PEA APHIDS



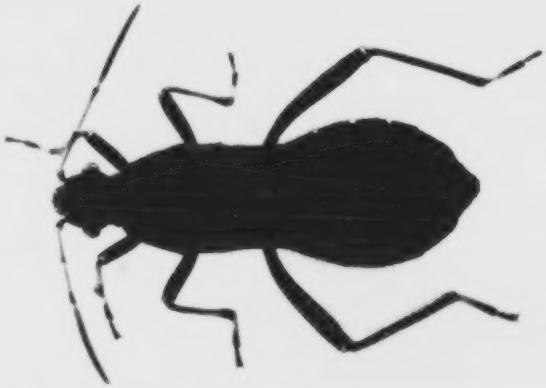
CLOSE-UP OF SYRPHID LARVA (6 MM IN BODY LENGTH) CONSUMING PEA APHID

The larvae are important predators of pest insects in legume forage crops. They hatch from oval, white, pebbled surface eggs that are usually laid singly among aphid colonies upon which they feed voraciously. The larvae are flattish, elongate grubs with a pointed head end and two spiracles (breathing tubes) at the other end. They vary in colour from brown to yellow or green with mottled whitish markings.

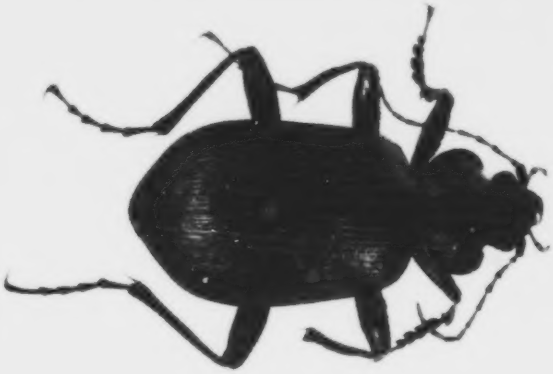
Green syrphid larvae are sometimes mistaken for alfalfa weevil larvae, but can be readily distinguished from them by the absence of a black head capsule. Syrphids overwinter as pupae on foliage, among plant debris or within the surface layer of soil. The pupae are enclosed within the remnants of the last larval skin and are brown and oval to pear-shaped in appearance.

OTHER PREDATORS IN FORAGE CROPS

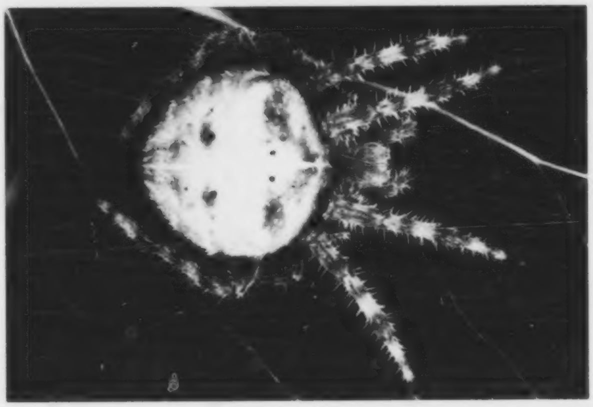
Several other predators are commonly found in forage fields. Both larvae and adults of rove beetles and many species of ground beetles are predacious. They are active mostly on the soil surface. Several large species of ground beetles (e.g. *Calosoma* spp.) that are known as caterpillar-hunters can kill large cutworms. Adults of soft-winged flower beetles, often red and blue (e.g. *Collops* spp.), are omnivorous and are often observed on flowers or grass inflorescences eating the pollen. The larvae are predacious. Adults of blister beetles are sometimes locally common and will occasionally cause minor damage by feeding on the leaves of legumes and canola. However, the larvae of some blister beetles are important predators of grasshopper egg pods. The larvae of some species of bee flies are also predators of grasshopper egg pods.



ASSASSIN BUG ADULT (7-10 MM IN BODY LENGTH)



GROUND BEETLE ADULT (7-15 MM IN BODY LENGTH)



THE ORB-WEAVING SPIDER (UP TO 30 MM IN BODY LENGTH) IS A GENERAL PREDATOR OF INSECTS

AMBUSH BUG ADULT (7-10 MM IN BODY LENGTH)

Ambush bugs and assassin bugs are sit-and-wait predators as both nymphs and adults. Adults can take quite large prey, including honey and leafcutting bees. Nevertheless, they can be important in the control of alfalfa pests. Adult robber flies are aerial predators of bees and a wide variety of other insects. The larvae live in the soil or decaying organic matter and are mostly predacious. Dragonfly adults prey on a wide array of small flying insects, including winged aphids. The immature stages of dragonflies are aquatic.

Predatory wasps, including hornets and yellow jackets, feed their larvae with caterpillars, weevil larvae and other insects. One species of sphecid wasp preferentially provisions its larvae with alfalfa weevil larvae. Most species of ants are scavengers and general predators.

Predatory mites and thrips prey on phytophagous mites and thrips as well as the eggs and hatchlings of other species. Although mites and thrips are often abundant in perennial forage, their effect is rarely recognized. However, they are commercially important as biocontrol agents in greenhouses and indoor landscapes.

All spiders, both immatures and adults, are general predators of insects and other arthropods. Because of their diversity, abundance and voracious appetite, they can play an important role in suppressing insect pest populations.

Parasitoids

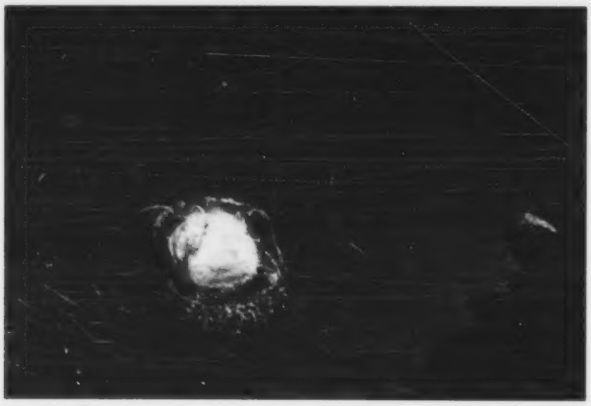
Thousands of species of parasitoid wasps and flies are in North America. Without them, outbreaks of pest insects would undoubtedly be much more common. The adults of many species need a source of nectar or pollen to maximize egg production; consequently, the availability of flowers, either within field or along roadsides, plays an important role in maintaining their populations.

APHID PARASITOIDS

The most common aphid parasitoids are tiny wasps that specialize in attacking aphids. Female *Aphidius* wasps insert an egg into each host aphid, and the developing larva completely consumes the internal tissues, leaving a light brown hardened remnant shell called a "mummy." Pupation occurs within the mummy from which the adult wasp emerges by cutting a circular hole.

Three species of *Aphidius* and one species of *Praon* are important for controlling pea aphids in Alberta. *Aphidius smithi*, the most successful parasite of the pea aphid, was introduced into California and the eastern United States from India and is now dispersed throughout most of the United States and many parts of Canada. It was first reported in Alberta in the early 1970s. Most aphid parasites have several generations per year and overwinter as mature larvae.

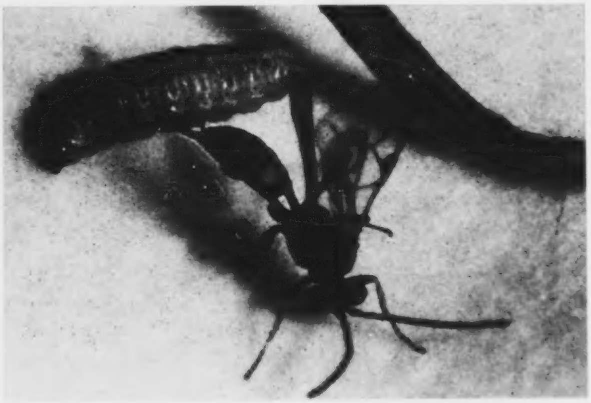
PARASITOID WASP SEARCHING FOR APHID



MUMMIFIED PEA APHID (2 MM IN SIZE)

ALFALFA WEEVIL PARASITOIDS

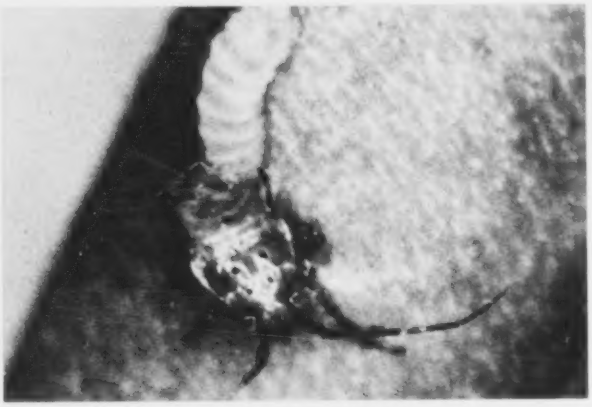
Much effort has been expended to release and establish exotic parasitoids for control of the alfalfa weevil, which is itself an inadvertently introduced species. The small ichneumonid wasp, *Bathyplectes curcurlionis*, has been successfully introduced from Europe. It is an internal parasitoid of the weevil larva and was first found in Alberta shortly after the alfalfa weevil was first found here. It is one of the important factors aiding in the control of this alfalfa pest in Alberta.



BATHYPLECTES WASP PARASITIZING ALFALFA WEEVIL LARVA

LYGUS AND ALFALFA PLANT BUG PARASITOIDS

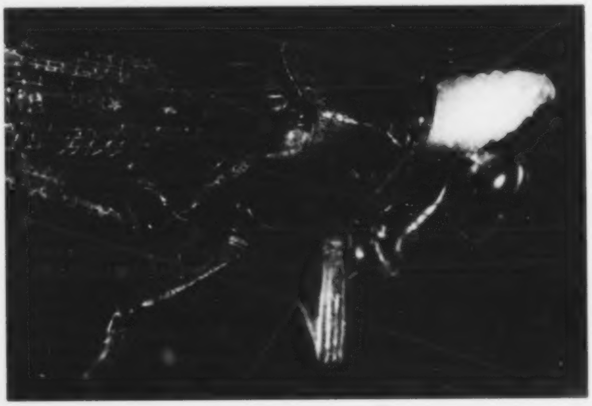
Lygus and alfalfa plant bugs are attacked by native braconid wasps in the genus *Peristenus*. These wasps lay their eggs in early instar nymphs of the host, and the developing larvae kill the later instar nymphs before they can become adults. There are a number of *Peristenus* species in Alberta, which vary geographically from north to south and also seasonally with the different generations of lygus bugs.



LARVA OF PARASITIOID WASP (2 MM) EMERGING FROM ABDOMEN OF LYGUS NYMPHAL HOST

PARASITOIDS OF OTHER INSECTS

Ichneumonid and braconid wasps and tachinid flies are common parasitoids of cutworms, loopers, armyworms, webworms and other caterpillars. The females of some ichneumonids have long ovipositors that enable them to parasitize concealed hosts. Grasshoppers are often parasitized by sarcophagid flies.

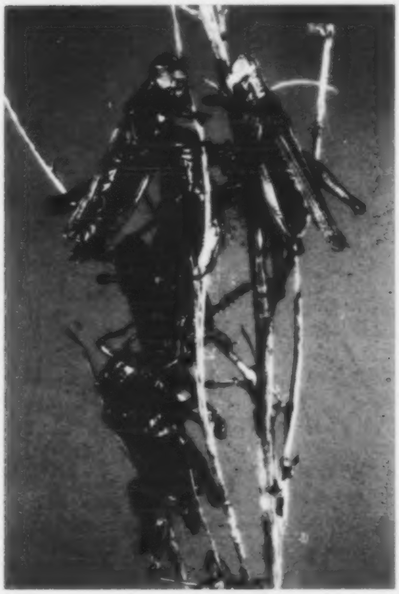


A SARCOPHAGID FLY LARVA PARASITOID EMERGING FROM A DEAD GRASSHOPPER

Beneficial insects are also attacked by parasitoids. The predatory western damsel bug, *Nabis alternatus*, is commonly parasitized by a braconid wasp and a tachinid fly. The pea aphid parasitoids in the genus *Aphidius* are themselves parasitized by two species of even smaller wasps. Ladybird beetles in Alberta are sometimes parasitized by a braconid wasp.

Pathogens

Fungi, bacteria, viruses and protozoans often infect insects and either kill them or reduce their fecundity. Pea aphids, grasshoppers and alfalfa weevils are often killed by fungi in the genus *Entomophora* and *Beauveria*. Infestations of armyworms and other caterpillars are sometimes terminated by viral diseases. Some virulent and host specific strains of fungi and viruses are being developed as biological insecticides.



CLUSTERED DEAD AND DYING TWO-STRIPED GRASSHOPPERS INFECTED BY THE FUNGAL DISEASE *Entomophora grylli*

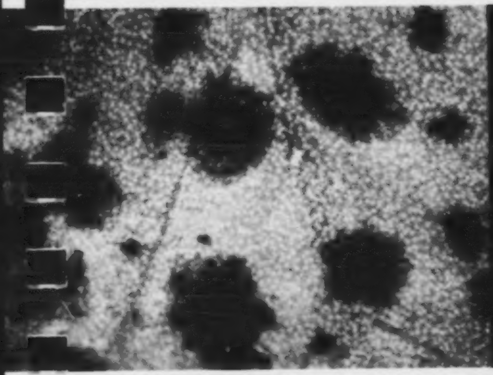
Bacillus thuringiensis (Bt) is a common soil bacterium that produces a toxin that is activated in the insect gut. Many different strains are specific to different insect groups. Bt is produced in commercial formulations for the control of some insects in high value crops. The ability to produce the Bt toxin has also been incorporated into some genetically modified crops.

Protozoans, usually microsporidia, can cause chronic infections that reduce longevity and fecundity. They are usually transmitted from generation to generation via the egg, but can also be transmitted by ingestion. Mass produced *Nosema* spp. have been tested for control of grasshoppers.

Pollinators

Many kinds of insects, especially flies and bees, visit flowers to feed on nectar or pollen and incidentally facilitate pollination. Legume crops either require or benefit greatly from pollination by bees. Honey bees, bumble bees and leafcutting bees are well known as important pollinators, but the contribution of many other kinds of wild bees is usually overlooked.

The most valuable North American crop requiring bees for pollination is alfalfa, and the commercial production of alfalfa seed now depends on management of the semi-domesticated leafcutter bee (*Megachile rotundata*). Pest control measures, especially in legume crops, must take into account the effect on pollinators.



FORAGE DISEASES

Forage Diseases

Forage crops in Alberta suffer from a multitude of diseases, both parasitic and non-parasitic. Parasitic diseases are caused by fungi, viruses, bacteria, phytoplasmas and even nematodes. Non-parasitic diseases are caused by unfavourable factors in the environment such as a nutrient deficiency, unfavourable acidity, high salts or temperature extremes.

Symptoms are the expression of disease in plants. Visual symptoms, such as necrotic lesions and a change in the colour or growth habit of the plant, can often be used to identify the disease. To confirm the cause of disease, the parasite must occasionally be isolated and identified in pure culture. A non-parasitic cause can often be identified from factors such as soil tests, weather records or farm practices.

Many pathogens are specific to a certain family, genus, species or cultivar. Pathogens may even be specific to a part of a plant. Specificity to particular cultivars is often utilized in breeding for resistance, which is the best tool in controlling plant diseases. Specificity to family, genus or species is utilized to control diseases through crop rotation.

Most pathogens infect either above or below-ground portions of a plant, but seldom both. Foliar pathogens are generally more host-specific and specialized than root pathogens. Many foliar pathogens can spread rapidly, often by wind. Their activity is very dependent on weather conditions. They are generally controlled by crop rotation, harvesting the forage crop early, burning the previous years' diseased crop residue in the spring before growth resumes or the use of resistant cultivars.

Root pathogens can be difficult to control because they occur (often initially at low levels) in soils throughout a region. The main defence against root diseases is to keep the crop as vigorous as possible by implementing good agronomic practices, such as seed inoculation, adequate fertilization and proper harvesting periods and by the use of fungicide seed treatments to enhance seedling establishment in fields where there is a history of root disease. When root diseases become severe, as indicated by excessive winterkill, weed invasion and reduced yield, the only option is to rotate out of the stand and reduce the population of root pathogens by growing non-host crops for several years.

Diseases of Alfalfa

Disease severity often increases over the life of the alfalfa stand. Seedlings are generally quite free of disease symptoms. Disease symptoms often appear in the second year, and by the fourth year, the stand may become thin and weedy. Stands grown for seed generally retain their plant density longer than those grown for forage, probably because a higher level of food reserves is maintained in the roots due to less frequent cutting. Rain-fed stands are less prone to disease than those grown under irrigation because many pathogens require moisture for infection and disease development.

The best way to maintain the productivity of alfalfa is to keep the stand as healthy as possible through good management. Select a cultivar with good winter hardiness, and maintain adequate soil fertility. Inoculate the seed to ensure strong nodule formation for nitrogen fixation, and treat it with a fungicide to reduce seedling infection by soil and seed-borne diseases. Avoid planting alfalfa on acidic soils.

The severity of foliar diseases can be reduced by cutting the crop early, before excessive leaf-fall can occur. The leaves are the most nutritious part of the plant, so early cutting maintains feed quality while removing the infected plant material that would otherwise be a source of infection for regrowth. Spring burning reduces the amount of infected crop debris, but should be done before crop growth begins to prevent crop injury.

To minimize losses from crown and root diseases, fertilize adequately and avoid harvesting the crop in late summer and early fall whenever possible. This approach allows the crop to replenish root reserves, which are necessary for winter survival and vigorous spring growth. See Crown Rot.

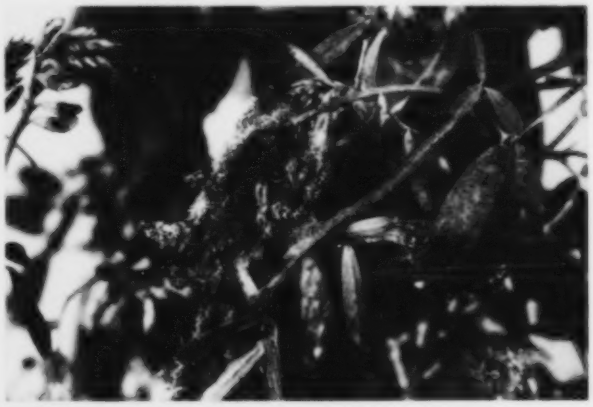
BLOSSOM BLIGHT

(Botrytis cinerea, Sclerotinia sclerotiorum)

Blossom blight reduces seed yield of alfalfa and other forage legumes by attacking flowers. This disease is favoured by cool wet conditions, which also reduce flowering and pollinator activity, and increases foliar disease severity. Infected flowers shrivel and die, but may remain attached to the flowering stalk for some time.

Mycelium grows rapidly from flower to flower. Infected plants flower, but the bloom does not persist, and pod set is slow. When blight is severe, blossoms hang in matted clumps, covered by grey or white mycelium. Blight is most severe in portions of fields with a dense plant canopy or reduced air movement.

Both pathogens survive as sclerotia in soil, and *B. cinerea* can survive in crop residue. Under cool wet conditions, the sclerotia germinate and produce air-borne spores that are carried by wind to flowers. Also, asexual spores of *B. cinerea* are produced on crop residue and infected flowers, and several cycles of infection may occur during flowering. Foliar application of a fungicide protects flowers from infection.



SEVERE BLOSSOM BLIGHT (CAUSED BY *Botrytis cinerea*) ON ALFALFA FLOWERS

BROWN ROOT ROT

(Phoma sclerotioides)

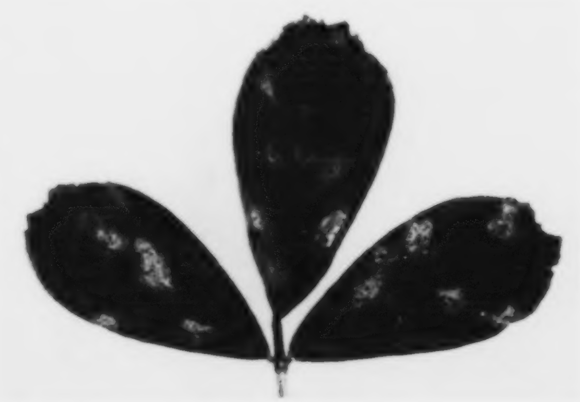
See Diseases of Sweetclover entry in this chapter.

COMMON LEAF SPOT

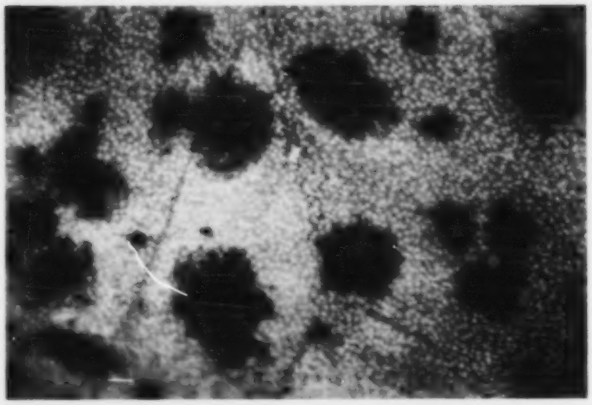
(Pseudopeziza medicaginis)

Common leaf spot occurs frequently on alfalfa in the southern areas of Alberta. Crop losses occur through reduced photosynthesis and loss of leaves. It also occurs on sweetclover. Small brown to black circular spots develop on infected leaflets. A small raised disc (the fruiting body of the fungus) can be seen in older spots using a magnifying glass. In spring and summer, spores are discharged and are carried by the wind to new growth. The pathogen overwinters in infected leaves, and the disease is favoured by wet weather.

Disease impact can be reduced by cutting the crop before defoliation becomes severe. No cultivars are resistant.



COMMON LEAF SPOT ON ALFALFA



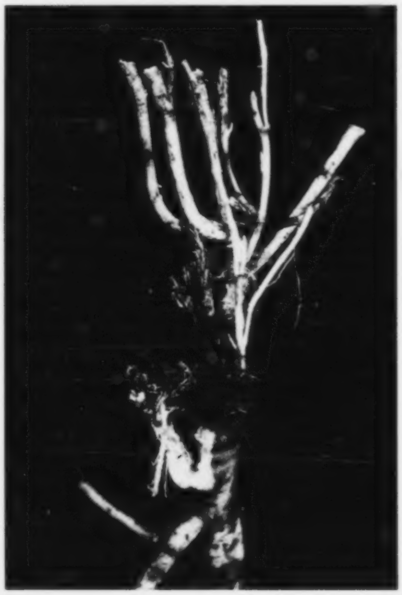
CLOSE-UP OF COMMON LEAF SPOT LESION – NOTE THE BROWN FRUITING BODIES

CROWN ROT

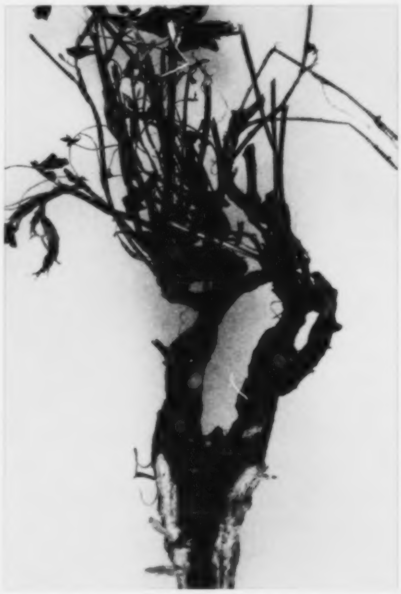
(Phoma medicaginis, Fusarium* spp., *Rhizoctonia solani)

Crown rot occurs wherever alfalfa is grown and can be found in almost every plant in every field in Alberta. As severity increases, the stand may become thin and susceptible to weed invasion, and yield may decline. Dark brown or black lesions develop on the bud tissue and spread to the crown and upper root areas. The pathogens also penetrate through wounds caused by insects, winter injury or mechanical damage, and overwinter in diseased crowns and in soil.

To minimize crown rot injury, promote plant vigour by maintaining soil fertility and avoiding cutting before the end of the growing season (allows plants to replenish root reserves). Rotate with resistant crops such as cereals for several years after an alfalfa crop to reduce the pathogen population. Cultivars with yellow flowers (indicating *Medicago falcata* parentage) such as Nordica are more resistant, but all cultivars are susceptible.



CROWN ROT OF ALFALFA – MUCH OF THE CENTRE OF THE CROWN HAS BEEN DESTROYED



CROWN ROT OF ALFALFA – A SECONDARY CROWN HAS FORMED TO REPLACE THE MAIN CROWN THAT HAS ROTTED AWAY

DAMPING-OFF AND SEEDLING BLIGHT

(Pythium* spp., *Fusarium* spp., *Rhizoctonia solani)

Many of the pathogens that cause crown rot also attack germinating seedlings. Infected seedlings rapidly wilt and die, which can reduce stand density and create gaps in the stand that are readily colonized by weeds. Damping-off is generally most severe when germination is slowed by factors such as seed with low vigour or damage from rough handling during seeding, cold wet soils, poor soil-seed contact, etc. Most forage crops can compensate for moderate reductions in seedling density, but severe losses can reduce yield and stand longevity.

To minimize damping-off and seedling blight, use disease-free seed lots with high vigour, and rotate with resistant crops to reduce pathogen populations in the soil. Treat seed with a fungicide if the risk of disease is high, such as a field with a history of establishment problems, or low seed quality, conditions that could result in slow emergence or where stand uniformity is particularly important, e.g. pedigree seed production.

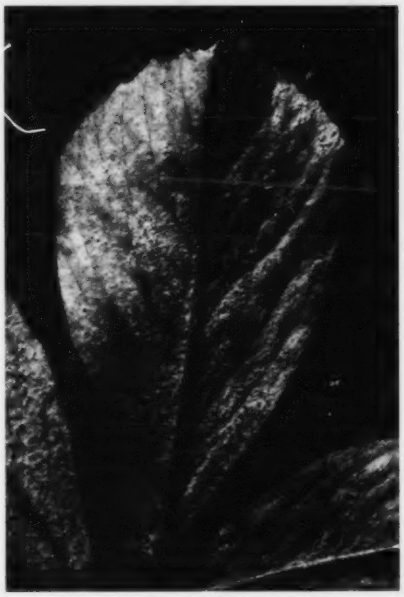
DOWNY MILDEW

(Peronospora trifoliorum)

Downy mildew often develops on alfalfa in wet years, but rarely infects sweetclover. The disease occurs in cool humid weather. Initially, light green to yellow blotches develop on the leaves. The top leaves of infected shoots are often small and twisted or rolled. Greyish fungal growth is visible on the underside of leaflets. The pathogen spreads into the crown and can overwinter in crown buds and in crop residue.

Control downy mildew through crop rotation and resistant cultivars such as Algonquin and Angus. Regrowth will often escape damage if the diseased crop is cut during warm dry weather.

DOWNY MILDEW OF ALFALFA – UPPER LEAF SURFACE



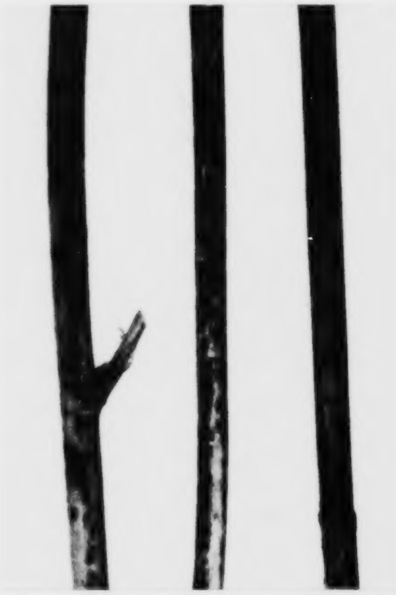
DOWNY MILDEW OF ALFALFA ON UNDERSURFACE OF LEAF – NOTE THE GREY MYCELIUM

SPRING BLACK STEM

(Phoma medicaginis)

Spring black stem disease occurs almost every year on alfalfa throughout the production areas of Alberta, but is favoured by cool moist weather. Small irregular dark-brown to black spots develop on the lower leaves, crown buds, stems, flower stalks, pods and even seeds. Severe infection causes leaves to turn yellow and drop off, and it kills young stems. The pathogen overwinters on seed, in crowns and crop debris.

Disease effect can be reduced by harvesting before excessive leaf-fall occurs or by spring burning to reduce levels of infected residue. However, burning after plant growth begins may cause plant injury. Rotate with non-legume crops. Treat seed with a fungicide to avoid seed-borne infection. There are differences in resistance among cultivars, but all are susceptible.



SPRING BLACK STEM ON ALFALFA STEMS

YELLOW LEAF BLOTCH

(Leptotrochila medicaginis)

Yellow leaf blotch disease occurs on alfalfa throughout Alberta, but is most destructive in northern areas. It appears initially as elongated yellow blotches that develop parallel to the veins on the lower leaves. Older blotches become brownish orange and develop linear patterns of dark dots in their centres. Blotches appear occasionally on stems. Spores from infected leaves do not mature until the following spring.

The disease may cause severe defoliation, resulting in forage losses of up to 15 per cent, together with a reduction in feed quality. Disease effect can be reduced by cutting before leaf drop, by spring burning and by crop rotation. Cultivars with yellow flowers are generally less susceptible than those with purple flowers.

VERTICILLIUM WILT

(Verticillium albo-atrum)

Verticillium wilt is one of the most destructive diseases of alfalfa in North America. It is widespread and severe under irrigation in southern Alberta, but only a few cases of the disease have been found in rain-fed fields. The main symptom is a reduction in the flow of water from roots to leaves.

The disease starts as a temporary wilting of upper leaves on warm days. This stage is followed by permanent wilting, and the leaves turn white or yellow. At first, the stem remains green. Later, the stem base may turn grey, then black from the growth of fungal spores. The vascular tissue in infected stems is often stained brown. Infected stems may be interspersed with healthy stems.

In Alberta, the productivity of infected fields often declines sharply in the third and fourth production years. Infected plants are very susceptible to winterkill. The disease is spread into new areas on infected plant debris carried with the seed and on machinery. Spread within a field generally occurs on machinery, especially during harvest operations.

Control verticillium wilt by selecting resistant cultivars and by planting clean seed treated with a fungicide. Plow down infested stands, grow non-host crops such as grasses or cereals and eradicate volunteer alfalfa for at least two years following an infected crop. Always harvest non-infested fields before infested ones, and clean and disinfest harvest equipment before moving between fields.

VERTICILLIUM WILT OF ALFALFA

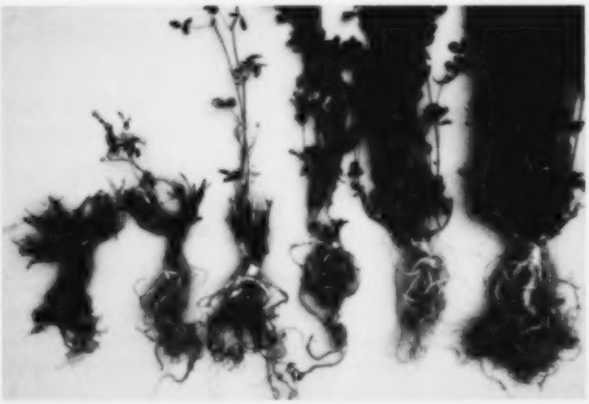
WINTER CROWN ROT

(low-temperature basidiomycete (LTB))
(formerly *Coprinus psychromorbidus*)

Winter crown rot disease is widespread and occasionally destructive in central and northern areas, especially in years when snow cover accumulates and persists before soil temperatures drop. All legume and grass forage crops are susceptible. A dark brown rot of the crown tissue develops under the snow during the winter and early spring, resulting in irregular patches of dead plants.

In alfalfa, the taproot below the infected crown is often white and healthy. Fluffy white mycelium may be visible on infected foliage immediately after snow melt. If only a portion of the crown is affected, individual plants may recover from infection, especially if the first cut is delayed to permit vigorous growth the following year.

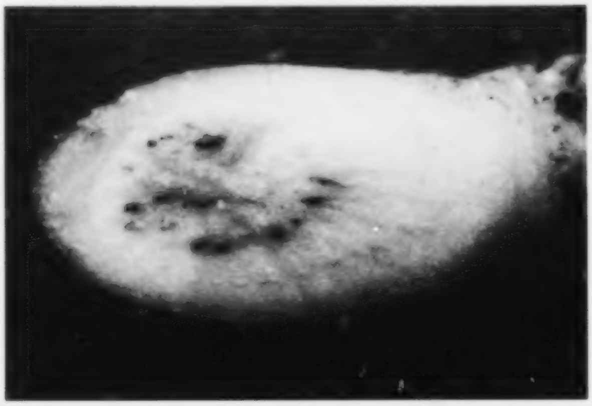
Control winter crown rot by planting winter hardy cultivars and by maintaining plant vigour. Cultivars with yellow flowers (indicating *Medicago falcata* parentage) such as Nordica are more resistant, but all cultivars are susceptible.



WINTER CROWN ROT OF ALFALFA (HEALTHY ON RIGHT)

BACTERIAL WILT OF ALFALFA (HEALTHY ON LEFT)

WINTER CROWN ROT – SYMPTOMS ON ALFALFA FOLIAGE IN SPRING



BACTERIAL WILT – NOTE THE DISCOLOURED VASCULAR TISSUE IN THE TAPROOT

BACTERIAL WILT

(Clavibacter michiganesis subsp. insidiosus)

Bacterial wilt only affects alfalfa and is most common in irrigated areas. Although the disease was very destructive in North America at one time, it has ceased to be a problem because almost all cultivars are highly resistant.

The pathogen enters plants through wounds produced by winter injury, insects or mechanical damage. Symptoms develop initially in the roots, where a yellowish orange to light brown stain develops in the vascular tissue. This discolouration eventually spreads to form a dark ring that is visible when the root is cut in cross section. By the second year, infected plants are stunted, yellowed, have small-cupped leaves and wilt during warm weather. Severely infected plants rarely survive the winter. The pathogen overwinters in infected roots and plant debris.

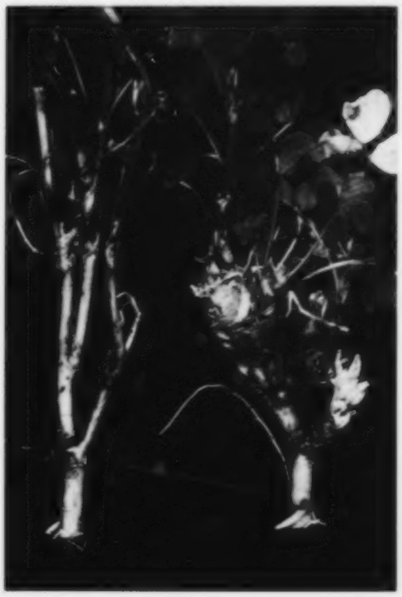
Bacterial wilt is managed primarily through the use of resistant cultivars. Stands of susceptible cultivars should not be retained for more than four years, especially under irrigation, and should not be followed by another alfalfa crop for at least two years. Clean and disinfest harvest equipment when moving between infested and non-infested fields.

BULB AND STEM NEMATODE

(Ditylenchus dipsaci)

Nematodes are small worms (<1 mm in length) that cause plant diseases in temperate regions. Some races of this nematode have a wide host range. The nematodes invade crown buds, which become swollen, brittle and deformed. Stems from infected buds are dwarfed, with thickened nodes, shortened internodes and wrinkled, discoloured tissues. In Alberta, damage is rare, but can occur in older stands under irrigation.

The stem nematode can carry wilt bacteria, resulting in disease on cultivars that are normally resistant to wilt. Control this pest by maintaining plant vigour and by limiting stand life to four years. Several resistant cultivars are available.



STEM AND BULB NEMATODE ON ALFALFA
(HEALTHY ON LEFT)

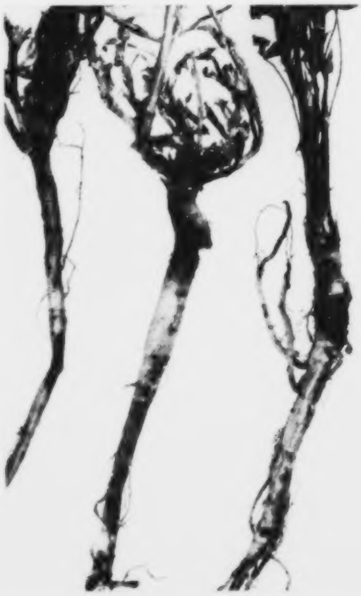
Diseases of Sweetclover

BLACK STEM
(Phoma pinodella)

See Diseases of Red Clover.

BROWN ROOT ROT
(Phoma sclerotioides)

Brown root rot is most severe on sweetclover, but it also affects alfalfa, true clovers and birdsfoot trefoil. The pathogen infects roots and spreads under a persistent snow cover during the winter, so symptoms are often not noticed until early spring. Affected plants are yellow and stunted and generally occur in irregular patches. Circular, dark brown lesions develop on the upper portions of the taproot and eventually spread into the crown. Small black balls (sacs of spores) form on the dead roots. Rotation with spring-sown crops is the main technique for disease management.



BROWN ROOT ROT ON SWEETCLOVER

COMMON LEAF SPOT
(Pseudopeziza meliloti)

See Diseases of Alfalfa.

DAMPING-OFF AND SEEDLING BLIGHT
(Pythium spp., Fusarium spp., Rhizoctonia solani)

See Diseases of Alfalfa.

GREY STEM CANKER
(Ascochyta viciae)

Grey stem canker disease occurs infrequently and usually causes minimal damage. Silvery white cankers form on the stems, leaf stalks and midribs of leaves; large cankers may girdle the stems. Small, dark brown dots (sacs of spores) form on the centre of the cankers. Heavily infected stems twist and bend at the top, are swollen and slow to develop and have few, small leaves. The pathogen can overwinter in seed or crop residue. Control grey stem canker through crop rotation and sanitation to remove infected plant residue.

Diseases of Red Clover

BLACK STEM
(Phoma pinodella)

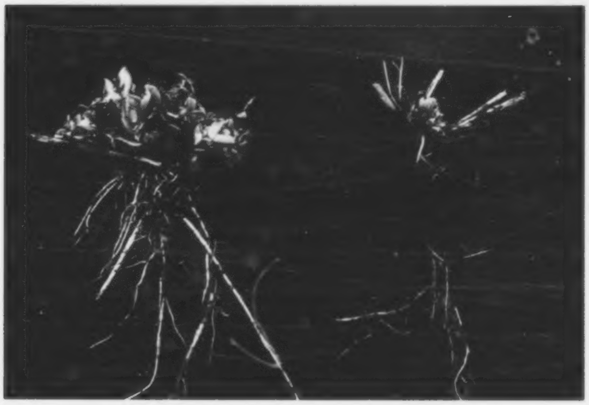
Black stem also infects alsike clover and sweetclover. The disease cycle and symptoms are similar to spring black stem of alfalfa. Black or dark brown areas develop on stems, leaves and pods. Heavily infected plants may drop their leaves. The disease is favoured by cool moist weather, so it tends to be most severe in spring and fall. Control black stem by rotating with non-legume crops, spring burning and cutting hay early.

BROWN ROOT ROT
(Phoma sclerotioides)

See Diseases of Sweetclover.

DAMPING-OFF, SEEDLING BLIGHT, ROOT ROT
(Pythium spp., Fusarium spp., Rhizoctonia solani)

See Diseases of Alfalfa.



FUSARIUM ROOT ROT ON RED CLOVER

NORTHERN ANTHRACNOSE
(Aureobasidium caulivora)

Northern anthracnose is very destructive on red clover, but alsike and white clover are fairly resistant. Cool humid weather favours disease development. Early symptoms are water-soaked areas on the stems and petioles. The lesions enlarge and turn dark brown, then become sunken, dry and lighter brown. Plant parts above the infected area wilt and die. Flower heads are often broken off by the wind. Stems and petioles usually curve to give the appearance of a shepherd's crook. Cracking of stem tissue is sometimes pronounced. The pathogen overwinters on infected crop residue, but can be seed-borne. The main control is crop rotation, but some cultivars, such as Norlac, are resistant.

NORTHERN ANTHRACNOSE ON RED CLOVER

Diseases of Red Clover

POWDERY MILDEW

(Erysiphe polygoni)

Powdery mildew is a serious disease of red and alsike clover. Severe epidemics reduce hay quality and yield of hay and seed. The disease is easily recognized by a light grey powdery layer (mycelium and spores) on the upper surface of leaves. Infected leaves become yellow and later brown. The pathogen overwinters on crop residue. No practical control measures are known.

POWDERY MILDEW ON RED CLOVER

SOOTY BLOTCH

(Cymadothea trifolii)

See Diseases of Alsike Clover.

WINTER CROWN ROT

(LTB)

See Diseases of Alfalfa.

Diseases of Alsike Clover

BLACK STEM

(Phoma pinodella)

See Diseases of Red Clover.

BROWN ROOT ROT

(Phoma sclerotioides)

See Diseases of Sweetclover.

DAMPING-OFF AND SEEDLING BLIGHT

(Pythium* spp., *Fusarium* spp., *Rhizoctonia solani)

See Diseases of Alfalfa.

POWDERY MILDEW

(Erysiphe polygoni)

See Diseases of Red Clover.

SOOTY BLOTCH

(Cymadothea trifolii)

Sooty blotch is common on alsike and white clover, but rarely appears on red clover. Conspicuous dark brown to black pustules form on the underside of leaves, which may shrivel and die. Severe infection reduces seed yield by preventing flowering. Infected foliage is toxic to livestock and may cause mouth ulcers. Cool moist conditions favour disease development. Control sooty blotch by rotating with non-hosts for three years, clean cutting to remove infected plant material and spring burning.

WINTER CROWN ROT

(LTB)

See Diseases of Alfalfa.

Diseases of Bromegrass

BROWN LEAF SPOT

(Pyrenophora bromi)

Brown leaf spot is common in Alberta, but is not usually severe enough to cause substantive losses in quality or yield. Elongated brown spots appear on young leaves early in the spring. Later, the spots enlarge and develop a yellow halo. Leaves wither and die from the tips downwards. Spots also occur on stems. The disease is favoured by humid weather and poor soil fertility. Control consists of clean grazing or cutting, stubble burning after harvest and maintaining soil fertility. Smooth bromegrass cvs. Baylor and Magna have some resistance, and severity is generally low on meadow bromegrass.

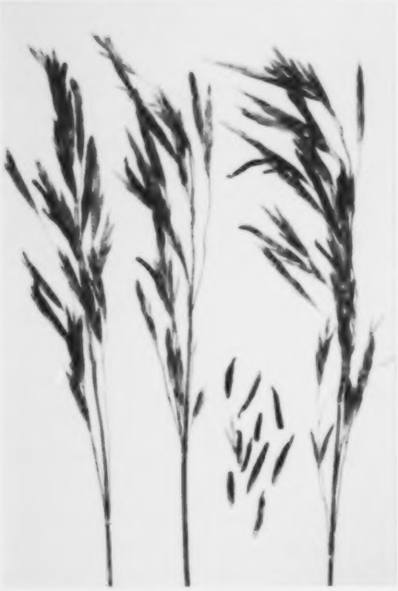
BROWN LEAF SPOT ON SMOOTH BROMEGRASS

ERGOT

(Claviceps purpurea)

Ergot is an important disease that affects a wide range of grass species. Ergot bodies (large, elongate, black sclerotia with a white interior) develop in place of seed. Livestock may be poisoned by ergot if allowed to graze on heavily infected stands or when fed infested seed screenings. Grasses in ditches, road allowances and headlands are frequently infected and act as sources of infection for adjacent crops.

Mow headlands and other grassy areas near crops before the grasses flower. After an infested crop, one option is to bury the ergot bodies by deep plowing. Clean infested seed thoroughly and store for one year before seeding to reduce the viability of the ergot bodies. Pollination problems associated with copper deficiency can increase the incidence of ergot.



ERGOT ON SMOOTH BROMEGRASS

FUSARIUM HEAD BLIGHT

(Fusarium spp.)

Fusarium head blight disease, mainly caused by the fungus *Fusarium graminearum* as well as several other *Fusarium* species, is important on wheat and barley, but it can affect many grasses and is responsible for ear and stalk rot in corn. Several *Fusarium* spp., especially *Fusarium graminearum*, can produce deadly toxins that render infected seed unfit for use as food or animal feed. The main toxin found is deoxynivalenol, which is produced largely by *Fusarium graminearum*. Yield losses are due to floret sterility and poor seed filling.

Fusarium head blight develops when wind or the splashing action of rain droplets transport spores from infested crop residues to cereal heads, especially when the crop is flowering. Premature ripening and shrivelling of infected areas occurs initially followed by the production of masses of small dark bumps (sacs of spores), while whitish, pinkish or orangey mycelium develop on bleached heads. Seed often appears shrivelled, lightweight and chalky white, which will lead to the downgrading of harvested grain.

The fungi may cause different diseases on other parts of the plant. Root rot or leaf infections may also appear on seedlings and adult plants of susceptible species (wheat, barley, grasses), while the planting of infected seed can result in seedling blight infections. The main fusarium head blight pathogens overwinter primarily on crop residue.

Fungicide seed treatments may increase emergence and reduce seedling blight, especially with infected seed or when planting into a field with a significant history of fusarium head blight. Removal of infected residue and rotation with non-host crops will reduce inoculum levels in the field, but infections may still arise from infested crop residues in adjacent fields. Improvements in fusarium resistance have been developed in wheat and barley, and while these improvements have not eliminated infections, fusarium-damaged kernels and toxin contamination of the grain, the levels will be reduced when compared with susceptible varieties.

HEAD SMUT

(Ustilago bullata)

The head smut pathogen attacks a wide range of grasses, especially meadow bromegrass and slender wheatgrass, but smooth bromegrass is not susceptible. Infected plants do not exhibit symptoms during vegetative growth. Instead, each seed is replaced by a ball of fungal spores. A thin membrane encloses the spores, which are released during harvest and contaminate the seedlot. They germinate when the seed germinates and infect seedlings. The pathogen overwinters in the crowns of infected plants and invades the new growth each spring. Seed treatment fungicides provide effective disease control.

FUSARIUM HEAD BLIGHT ON ANNUAL BLUEGRASS
(AFFECTS A WIDE RANGE OF GRASS SPECIES)

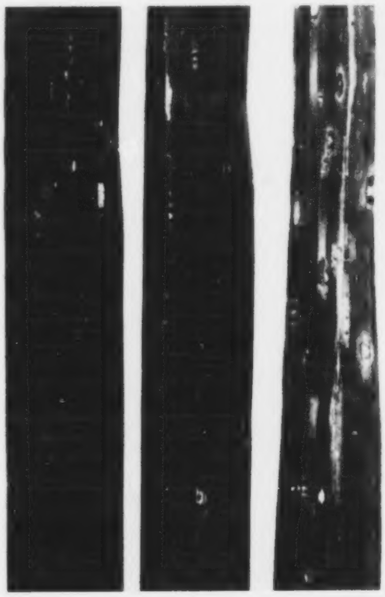
HEAD SMUT ON MEADOW BROMEGRASS

Diseases of Bromegrass

LEAF AND CULM SPOT

(Pseudoseptoria bromigena)

Leaf and culm spot is widespread on bromegrass in Alberta, but is not usually severe except under prolonged humid weather. Brown spots occur on leaves, sheaths, stems and floral parts. In the early stages, symptoms are similar to those of brown leaf spot. However, mature spots have dark brown borders and pale centres with black dots (sacs of spores). Severely affected leaves wither from the tip downward. Spores are released in the spring and are spread by wind and rain. Control consists of crop rotation, clean grazing or cutting and stubble burning. Smooth bromegrass cv. Magna has some resistance, and severity is generally low on meadow bromegrass.

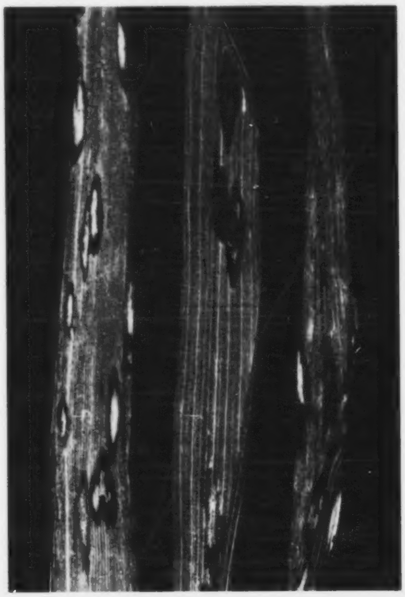


LEAF AND CULM SPOT ON SMOOTH BROMEGRASS

SCALD

(Rhynchosporium secalis)

As with leaf and culm spot, scald is widespread on bromegrass in Alberta, but is not usually severe except under prolonged humid weather. Pale grey spots with dark margins develop primarily on leaves. Control consists of crop rotation, clean grazing or cutting and stubble burning. Severity is generally low on meadow bromegrass.



SCALD ON SMOOTH BROMEGRASS

SILVERTOP

(Cause unknown)

See Diseases of Fescue.

SNOW MOLD

(Sclerotinia borealis, Typhula* spp., LTB, *Microdochium nivale,* and *Phoma sclerotioides)

See Diseases of Fescue.

Diseases of Fescue

ENDOPHYTE
(*Epichloë typhina*)

Fungal endophytes inhabit many grasses, including species of fescue, ryegrass and occasionally bluegrass and bromegrass. They live inside the plants and are carried to the next generation in infested seed. Endophyte-infected plants do not develop symptoms but often have improved stress tolerance (drought, weed competition, overgrazing), better water use efficiency and produce alkaloids that deter insects feeding.

Commonly identified alkaloids harmful to livestock include ergovaline (found in tall fescue or fine-leaved fescue varieties) and Lolitrem B (found in some perennial ryegrass varieties). Ergovaline can cause poor growth, lowered fertility, shedding of hooves, ears and tails, staggers, convulsions and even death in livestock grazing on or fed on hay or screening from infected fields. Lolitrem B can cause ryegrass staggers; however, animals do not show signs of the condition until they are excited. Animals can experience problems ranging from tremors to severe lack of coordination and falling down.

In Alberta, the main source of endophyte-infected feed is fields of turf-type tall fescue and perennial ryegrass grown for seed. The level of endophytes will vary among varieties. Growers should always check toxin levels in feed from such fields before feeding it. Endophytes can be eliminated from seed by prolonged storage or short-term storage under hot, moist conditions.

ERGOT
(*Claviceps purpurea*)

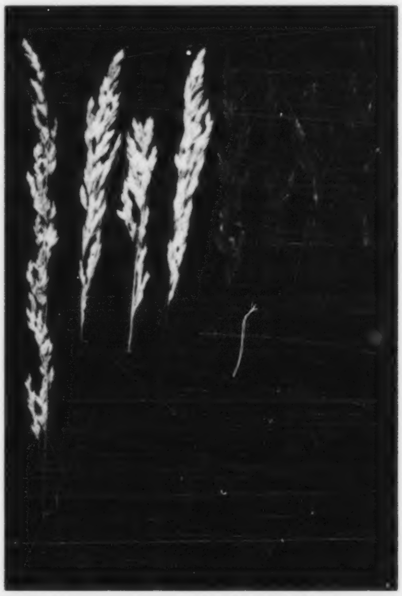
See Diseases of Bromegrass.

SILVERTOP
(whiteheads)

Cause unknown.

Silvertop occurs frequently in older stands grown for seed in a range of grasses, including wheatgrass, bluegrass, bromegrass and fescues. It often becomes more severe in successive years. Affected heads have a bleached appearance above the apical node in the stem and contain no seed. Below that node, the stem is green and appears healthy. Above the node, the stem is shrivelled, discoloured or rotted and is easily pulled out of the surrounding leaf sheath. Damage from stem-feeding insects is often visible. However, no insect or pathogen has been consistently associated with this symptom.

Close mowing and removing residue from the field after harvest may reduce levels of silvertop the following year. Burning after harvest or in the spring on grass seed crops that tolerate burning or an insecticide application before stem elongation in spring may reduce silvertop incidence. Certain grass species and cultivars have a lower incidence than others, but no cultivars are resistant.



SILVERTOP ON KENTUCKY BLUEGRASS (HEALTHY ON RIGHT)

SNOW MOLD
(*Sclerotinia borealis*, *Typhula* spp., LTB (formerly *Coprinus psychromorbidus*), *Microdochium nivale*, and *Phoma sclerotioides*)

Snow mold is a fluffy, white or grey fungal mycelium that grows at temperatures near 0°C under a deep snow cover in winter. It is visible on circular patches of grass immediately after snow melt. Small brown to black sclerotial bodies are often attached to the leaves and stems of affected plants. Resistance to snow molds depends on the vigour and food reserves of the plant and on the depth and duration of snow cover.

Control snow molds in stands grown for seed production by removing debris of the previous crop and applying enough nitrogen late in the fall to bring the total up to 50 to 70 kg N/ha for first crops and 70 to 100 kg N/ha for subsequent and rejuvenated crops. Rotate fescue with spring-sown crops.

LOW-TEMPERATURE BASIDIOMYCETE (LTB) SNOW MOLD ON FINE TURF – AREA AT RIGHT WAS TREATED THE PREVIOUS FALL WITH A FUNGICIDE

STEM EYESPOT

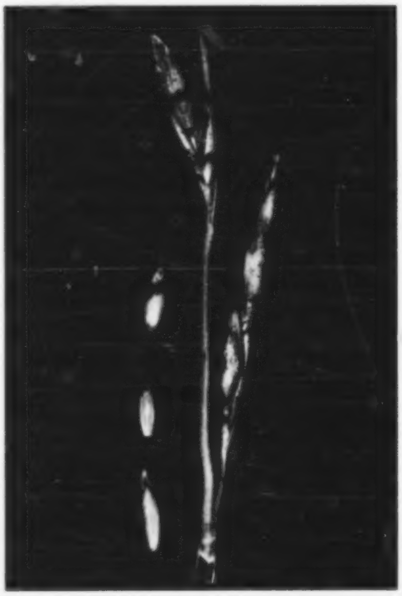
(Didymella festucae)

Stem eyespot is confined to fescue grasses particularly creeping red fescue. It attacks stems, so affects seed production but not turf or forage. Stem eyespot gradually builds up in the field and can cause significant losses in second and third-year stands. Stem eyespot can be a major disease on creeping red fescue fields in Northern Alberta.

The disease is characterized by brown to purple-brown spots, often with light centres, that develop on flowering stems. Spots also occur on the leaf sheath, flower parts and seeds. Leaf spots are rare. Seed does not develop on infected tillers. Maximum seed production can be achieved in the first year by using high seeding rates (6-10 kg/ha) and by applying high levels of nitrogen in the fall.

Direct control can be achieved when rejuvenating a stand by using a hot burn (lots of residue on the field) to remove all debris and stubble, followed by tillage. In northern areas, burning prevents seed production the following year, so it should be used only as a part of rejuvenation.

STEM EYESPOT ON STEMS OF RED FESCUE GROWN FOR SEED



STEM EYESPOT ON SEED HEAD

Diseases of Timothy

ERGOT

(Claviceps purpurea)

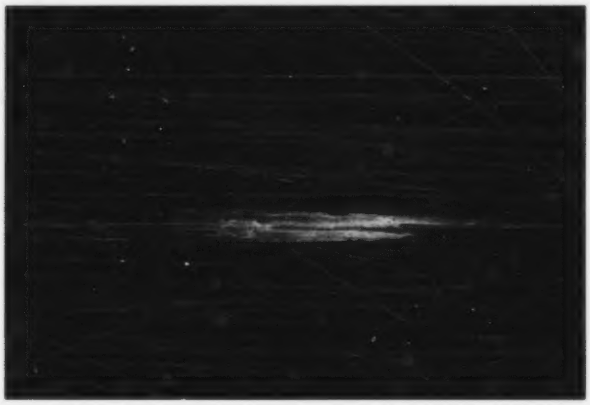
See Diseases of Bromegrass.

LEAF STREAK

(Drechslera phlei)

Leaf streak is rarely destructive in Alberta. However, the disease is seed-borne and may be a problem in moister climates where the seed is used. Indeterminate longitudinal light brown streaks occur on the leaves, often along the margins. Later, the leaves wither and die from the tips downward causing a loss of hay quality and, in severe cases, seed yield.

Control consists of crop rotation, clean grazing or cutting, stubble burning and maintaining soil fertility. No cultivars are resistant.



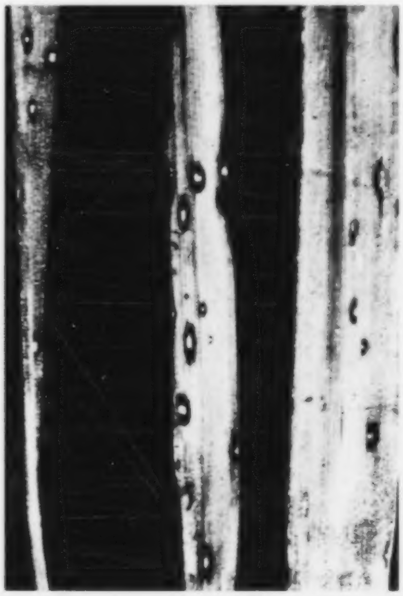
LEAF STREAK ON TIMOTHY

PURPLE EYESPOT

(Cladosporium phlei)

Purple eyespot is widespread in Alberta, but is only occasionally severe. Severe infections will reduce feed quality and seed yield. Purple-brown oval spots with light greyish brown centres develop on the leaves. Severely affected leaves wither and die from the tip down. Cool humid weather favours disease development.

The disease is more severe when soil fertility is low, so growers should ensure that nitrogen and phosphorus levels are adequate. Burning stubble after seed harvest reduces levels of disease, but may damage the stand. North American cultivars generally have more resistance than those from Europe.

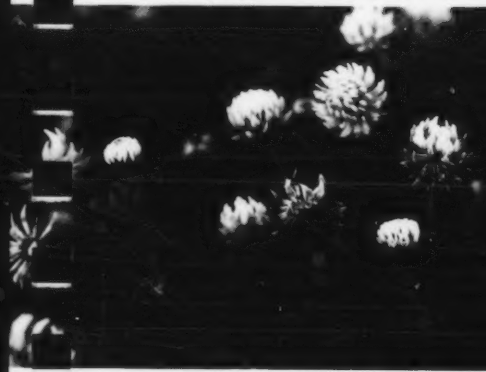


PURPLE EYESPOT ON TIMOTHY

SNOW MOLD

(Sclerotinia borealis, Typhula* spp., LTB, *Microdochium nivale,* and *Phoma sclerotioides)

See Diseases of Fescue.



GLOSSARY

Glossary

Acidity
An acid quality or state. Solutions with pH below 7.0 show acidity. Acid is the opposite of alkaline or basic. An acid compound yields hydrogen ions when dissolved in water.

Acid Detergent Fiber (ADF)
The highly indigestible portion of the forage (lignin, cellulose, silica) is called acid detergent fiber. ADF is generally used to calculate digestibility and energy. Forages with a high ADF level have a lower digestibility and lower energy than forages that have low levels of ADF.

Adventitious Roots
Roots originating from the nodes at the base of the tillers and the nodes of rhizomes and stolons, which become the dominant root system for the grass. Grasses have mainly adventitious roots.

Aftermath
Residual or regrowth of forage produced after haying or grazing. Aftermath growth is sometimes grazed in the fall, after plants have become dormant.

Alkaline
An alkaline soil is one with a pH above 7.0, the opposite of acidic.

Alkaloids
Alkaloids are amines or organic compounds produced naturally by some forage species. Alkaloids can cause poor palatability and potential toxicity of some grasses for livestock. Some grasses such as reed canarygrass have varieties with high levels of alkaloids. Newer varieties of reed canarygrass have low levels of alkaloids.

Allelopathy
Allelopathy is the harmful effects of one plant on another plant by the release of chemicals from plant parts through leaching, root exudation, volatilization, residue decomposition, etc. These actions are a process a plant uses to keep other plants from growing too close to it.

Animal Units (AU)
An animal unit is based on forage consumption by a 454 kg (1,000 lb) cow with or without a calf. An animal unit month (AUM) consumes approximately 380 kg/month (840 lb/month) of forage based on a daily consumption of 13 kg/day (28 lb/day).

Animal Unit Equivalent (AUE)
The animal unit is adjusted for other animals by adjusting for animal type, class or size and is given animal unit equivalents (AUE). This figure adjusts for animal weight and intake. A 454 kg (1,000 lb) cow with or without a calf is one animal unit and a yearling heifer 300 kg (700 lb) has an animal unit equivalent of 0.67.

Annual
Plants that germinate, establish, flower, set seed and die in one growing season.

Anthesis
The stage when pollen is shed during flowering.

Anti-quality
In forage, the term means having a negative effect on daily intake, productivity or health of livestock.

Auricle
An appendage located at the base of the grass leaf blade where the blade is attached to the sheath. Auricles are generally paired, arising from opposite margins of the leaf, may be rudimentary or claw-like and may wrap around the stem until the pairs overlap.

Autotoxicity
Autotoxicity is a type of allelopathy where a species, through the production of chemicals that escape or are released into the soil, directly inhibits the growth of that same species. Alfalfa autotoxicity is the process in which established alfalfa plants produce a chemical or chemicals that escape into the soil. This chemical prevents the establishment or reduces the growth of new alfalfa plants if seeded too soon following an old stand or if trying to no-till new alfalfa seed into an established alfalfa field.

Awn
A slender bristle, usually found projecting from the back or tip of a lemma (outer seed coat) or glume. Awns can be short or long and are sometimes called beards.

Axil
The upper angle between a branch or leaf where it is attached to the stem.

Basal
The part of an organ, such as a leaf, nearest its point of attachment. At the base, for example, basal leaves are produced from the base of the plant, at or near ground level.

Basic
Solution with pH above 7.0, the opposite of acidic. Basic is the same as alkaline. Basic compounds react with acids to produce salts.

Biennial
A plant that completes its life cycle in two years. A true biennial is a plant that germinates, establishes and produces only vegetation in its first year and then produces vegetation and seed and dies in its second year. Sweet clover is a biennial.

Blade
The expanded, wide, usually flat part of a leaf. In grasses, the blade extends from the sheath and away from the stem.

Bloat
Excessive accumulation of gases in the rumen.

Boot Stage
The stage in grasses when the head is enclosed by the sheath of the top leaf, also called the flag leaf stage. The flag leaf is the last leaf produced by the tiller.

Bud
An unexpanded leaf, shoot, branch or flower.

Buffering Capacity
The amount of resistance to a change in the pH of a solution. In silage making, it is the degree to which forage material resists changes in pH. Forages with a high buffering capacity, such as alfalfa and clover, are resistant to a decrease in the pH (increase in the acidity), which is needed to preserve them. Plants have varying degrees of buffering capacity.

Bunchgrass
Grasses that produce no rhizomes or stolons, tufted.

Canopy
The above-ground portion of a plant stand. It may be expressed as percentage of ground cover.

Carbohydrate
Compounds, such as sugars, starch and other soluble carbohydrates (nonstructural) and cellulose and hemicellulose (structural), that are made of carbon, hydrogen and oxygen, usually in the ratio of 1:2:1 (CH_2O).

Cellulose
A carbohydrate formed from glucose that is the major constituent of the plant cell walls.

Carrying Capacity
The maximum total stocking rate that can be achieved over a specified length of time (for example AU/ha for the grazing season). The sum of all grazing days and stocking rates will determine the maximum carrying capacity of the pasture, which maintains a target level of production without affecting the ecosystem.

Collar
In grasses, the collar is located on the outside of the leaf, where the blade attaches to the sheath.

Companion Crop
A companion crop is a cover crop (usually a cereal crop) grown with a perennial forage during the establishment year, but may also include annual or short-lived forage species in mixtures. Companion crops are competitive with forage seedlings.

Compound Leaf
A leaf that is divided into two or more parts (leaflets).

Continuous Grazing
A grazing practice where grazing is on one pasture and the livestock have unrestricted access for long grazing periods.

Cool-season Plants
Plant species that grow best in cool temperatures (15 - 25°C). In photosynthesis, they first produce a 3 carbon acid (3 - phosphoglyceric acid) to make carbohydrates. This C3 photosynthesis occurs at cooler temperatures than C4 photosynthesis, but is less efficient at warmer temperatures. All perennial forages used in Alberta are cool-season species.

Coumarin
Coumarin changes to dicoumarol, an anticoagulant, when the hay from forage species containing coumarin becomes moldy. Anticoagulants prevent blood from clotting. Coumarin was once commonly found in sweet clover, but newer varieties are coumarin-free.

Creeping Root
An underground stem, a rhizome.

Cross-pollinate
Transfer the pollen from the flower of one plant to the flower of another plant of the same species.

Crown
The portion of a plant where the stem and the root meet and where tiller buds and rhizomes are first formed. The crown of perennial forages overwinters to produce new tillers and additional rhizomes in the spring.

Crude Fibre
This is the fibrous part of the plant that has very little nutritional value and is not very digestible. Cellulose is an example of the fibre in the plant. The terms acid detergent fiber (ADF) and neutral detergent fiber (NDF) are generally used instead of crude fiber.

Crude Protein
Proteins are made up of amino acids. Protein is determined by measuring the nitrogen in the forages and multiplying by 6.25. Plant proteins are used by the animal to produce animal proteins (e.g. meat and milk).

Decreaser Species
Decreaser species are well liked by livestock and are the first forage species in excellent condition rangeland to decrease in abundance if grazing is too heavy.

Decumbent
A plant stem with the base lying on the ground and the tip growing upright is called decumbent.

Determinate
Plant structures that have a determinate, limited growth period and do not continue growth indefinitely. They grow for a limited time until they reach a certain size or level of maturity and then stop growing, such as the growth form where the terminal growing point develops a flower and terminates the vegetative growth of the shoot, e.g. red clover has determinate shoots.

Digestibility
Refers to the proportion of the forage digested by the animal. The digestibility is generally expressed as a percentage. Digestibility may be expressed as digestible dry matter (DDM), which is the forage dry weight minus the feces dry weight. In vitro digestibilities are determined in a laboratory using rumen microflora in a test tube.

Diploid
A plant with two sets of chromosomes in its cells.

Dominance
This is where terminal buds of a plant or shoot inhibit the development of lateral buds.

Dry Matter
Feeds are heated in an oven to eliminate the moisture in a sample to determine the moisture-free weight of the sample. This process enables samples to be compared more accurately on an equal 100 per cent moisture-free basis.

dS/m
DeciSiemens per meter is a measure of electrical conductivity of a solution and is used to determine the salinity of soil.

Endophyte
A living organism that lives all or part of its life cycle inside its host plant in a parasitic or symbiotic relationship.

Erect
Upright

Facultative Apomict
A plant such as Kentucky bluegrass that can reproduce sexually or asexually. Facultative apomicts produce seed by vegetative means or apomixis. Apomixis is an asexual (no fertilization of the male or female plant parts) form of seed set in the floret. Facultative apomicts can also produce seed by cross pollination (sexual fertilization of the pistil by pollen).

Fibrous Roots
Very fine, thread-like roots. Grasses have fibrous roots.

Floret
In grasses, the floret is the flower that develops to be the seed, lemma and palea.

Forage
A forage crop is one grown for pasture, hay or silage. The vegetative plant material, including stems, leaves and heads, used for livestock feed. Grasses are often developed for suitability for forage (i.e. forage types) versus turf or reclamation types, etc.

Glaucous
A slightly waxy often bluish or whitish coating on plants that can be rubbed off.

Glumes
A bract (scale-like leaf) attached near the base of a grass spikelet. Glumes may be broad or narrow and may have an awn.

Grass
Plants that are members of the *Poaceae* plant family. Grasses are monocotyledons with parallel leaf veins. Stems are usually round but may be somewhat flattened and usually hollow, except at the nodes.

Haplocorm
A bulb-like, solid portion of stem below ground level from which new shoots develop, such as those found at the base of timothy stems. Haplocorms are important for carbohydrate storage.

Hard Seed
Seed with a seed coat that is impervious to water and will not germinate, even though it is viable. Legumes commonly produce seed with a high portion of hard seed. Hard seed will de-harden in the soil over time, due to freezing and thawing, etc. Hard seed can also be scarified (etched or scratched) by mechanical or other means to enable it to take up water more quickly and germinate.

Heading
Grasses are heading from the time the head begins to emerge from the boot until it is fully out of the boot. The stem continues to grow and elongate, elevating the head, even after heading is complete.

Hexaploid
A plant with six sets of chromosomes in each plant cell.

Increaser Species
Increaser rangeland plant species tend to increase in abundance and take the place of the decreaser species under continued heavy grazing pressure. The increasers will also begin to decrease when heavy and close grazing continues on an on-going basis.

Indeterminate
Indeterminate growth is growth that is not terminated once a genetically pre-determined structure has completely formed as it does when the growth is determinate.
A plant that grows and produces flowers until killed by frost or some other external factor is called indeterminate. These plants have flowers on lateral branches, enabling the stem to continue vegetative growth. Indeterminate plants flower over an extended period. Examples include alfalfa and alsike clover.

Inflorescence
The flowering structure of a plant or the arrangement of the flowers of a plant. The inflorescence can be a head, raceme, spike, panicle, etc.

Inoculate
The application of nitrogen-fixing rhizobia bacteria to the seed of legumes. These bacteria are forage species specific or may be appropriate for a group of forage legumes. For example, the same rhizobia species can be used for alsike, red and white clover.

Internode
The portion of a stem between the nodes. Internodes lengthen as grass stems grow and elongate.

Introduced Forage
A species that is not naturally present in the vegetation of an area but that is brought in from another country or region, e.g. alfalfa.

Instar
The development stage of the nymph form of an insect. The nymph will go through several moults, producing new instars between each moult before it becomes an adult.

Invader Species
Plants that are absent from climax rangeland, but will invade under disturbance or continued overuse.

IVDMD – In Vitro Dry Matter Disappearance
A method of estimating the dry matter lost following the incubation of the forage in rumen micro flora in the laboratory. IVDMD is expressed as a percentage of the initial sample and is a measurement of the digestibility of the forage.

IVDOM – In Vitro Digestible Organic Matter
In vitro digestibilities are determined in a laboratory using rumen microflora in a test tube. IVDOM refers to the proportion of the forage organic matter digested by the animal. It is generally expressed as a percentage and is used as a measure of digestibility.

Larva(e)
The juvenile form of an insect. The larva can look completely different from the adult insect, i.e. the caterpillar is a larva whereas the butterfly is the adult.

Lateral Root
A branch off the primary root. It is often small, but may be as large as the primary root.

Lax
Droopy, weak, hang down, not stiff.

Leader-follower Grazing System
A grazing system where livestock requiring high quality forage graze the paddock first and graze the highest quality parts of the plant, followed immediately by animals requiring lower quality forage, which graze the remaining residue. An example of this system is milking cows grazed first, followed by non-milking cows.

Leaf Axil
The junction where a leaf attaches to a stem. See "axil."

Leaf Blade
The expanded portion of a leaf. See "blade."

Leaflet
A division of a compound leaf. For example, white clover leaves have three leaflets.

Leaf Margins
The edges of a leaf.

Leaf Sheath
In grasses, the lower portion of the leaf that surrounds the stem. It is below the blade. Grass sheaths may have open, closed or overlapping margins.

Legume
A plant in the *Fabaceae* family. This family is made up of broadleaf forbs that have a symbiotic relationship with rhizobia bacteria, which fix atmospheric nitrogen. Alfalfa, clovers, etc. are examples of legumes.

Lemma
Together with the palea, the lemma encloses the grass flower or seed. Relative to the palea, the lemma is usually longer and attached lower to the outside of and with its edges overlapping the palea. The lemma may have an awn. Most grass seeds have the lemma and palea attached after threshing, e.g. bromegrass, fescue, wheatgrasses. The lemma and palea are sometimes called hulls.

Ligule
In grasses, membranous tissue located between the stem and the leaf blade, near where the blade attaches to the sheath.

Loam
A medium textured soil composed of a desirable portion of sand, silt and clay.

Lodging
Lodging is the breaking or bending of stems near the base so that the plants lie on the ground, often due to weak stems. Plant height, wall thickness and cell wall lignification can affect lodging. Tall plants have a higher tendency to lodge than short plants. Adverse weather conditions such as winds and heavy rains can cause lodging as well.

Lt50
The lethal temperature that kills 50 per cent of plants.

Midrib
The central vein of a leaf.

Multifoliate
Having several leaflets. Normal alfalfas have three leaflets, whereas multifoliates can have up to eleven leaflets. Multifoliate alfalfas in Alberta generally only have five leaflets.

Mycelium
Mycelium is the vegetative part of a fungus consisting of a mass of branching, thread-like or tubular filaments called hyphae.

Native Plant
A plant that is indigenous to or originating from an area, the opposite of introduced, e.g. Western wheatgrass is native to Alberta.

Naturalized
Introduced plants that are well adapted to a region and have become established in the local ecosystem over time. Examples of naturalized plants in Alberta include white clover and Kentucky bluegrass.

Nematodes
Nematodes are the most abundant multicellular life forms on earth, but are often overlooked because most of them are microscopic in size. Most nematodes are beneficial organisms that break down and release nutrients from organic matter. Several plant-parasitic species of nematodes feed on roots or stems causing damage to plants, which can affect yields.

Neutral Detergent Fiber (NDF)
The indigestible and slowly digestible components (cellulose, hemicellulose, lignin and ash) in the cell walls of the plant are called neutral detergent fibers (NDF). This is a more complete measure of fiber in the forage than acid detergent fiber (ADF), and the NDF levels are always higher than ADF. NDF is a good indicator of the potential intake of forage; as NDF increases, intake decreases.

Nitrogen Fixation
The symbiotic relationship between rhizobia bacteria and a legume where the bacteria form a nodule on a root or root hair and convert atmospheric nitrogen available in the air between the soil particles into a nitrogen form that is usable by the plant.

Nodes
The point from which growth occurs on a stem and a point from which leaves develop and are attached. On grass stems, a node appears as a swelling, which is solid on the inside.

Nodule
In legumes, a small growth on a root where rhizobia bacteria fix atmospheric nitrogen and convert it to ammonia, which plants can use.

Nymph
The immature form of some insects before reaching the adult stage. A nymph's overall form resembles that of the adult, and the final moult results in an adult insect.

Paddock
A smaller, fenced pasture, a subdivision or one of many subdivisions of a larger grazing area. Paddocks enable better control of the grazing of the pasture.

Palatability
The acceptability of a plant to the livestock grazing or consuming it. Given a choice, livestock will find one forage species or parts of the same forage more palatable than another.

Palea
The inside bract (scale-like leaf) of the two bracts that enclose the grass flower or seed. The palea is more membranous than the lemma.

Palmate
Divided or lobed. On palmate legume leaves, the leaflets arise from a common point, without a stalk. Examples include the leaves of alsike, kura, red and white clover.

Panicle
A multi-branched cluster of flowers, each with its own stalk. A panicle has a subdivision in addition to that of a raceme. The lower branches have longer stalks and open first. Bromegrass, fescue, bluegrass and oats have panicles.

Parasitoid
Insect parasitoids have an immature life stage that develops on or within a single host, which it ultimately kills and often consumes in the process. Parasitoids differ from parasites, which live side by side with the host without killing the host.

Pathogens
Pathogens are infectious agents that can cause a disease or illness to its host.

Peduncle
The stock of a solitary flower or flower cluster. For example, in white clover, the peduncle supports the flower head. It is sometimes called a flower stalk.

Perennial Plant
A plant that persists for more than two years. For legumes and grasses commonly used for forage, the shoots are annual and regrow from the perennial crown in spring.

Petiole
A leaf stalk. It attaches the leaf to the stem.

pH
Solutions may be acidic (below pH 7.0), neutral (pH = 7.0) or basic (pH above 7.0). Basic is the same as alkaline. The pH scale is logarithmic, e.g. a solution with an acidity of 5.0 is ten times more acidic than one with a pH of 6.0.

Photosensitization
An abnormal reaction or sensitization of the skin of an animal to sunlight due to a compound present in forage that has been eaten by the animal.

Photosynthesis
The process by which green plants use the energy from sunlight to produce carbohydrates from carbon dioxide and water.

Phytoplasmas
Phytoplasmas are parasites and pathogens of plants and insects. All known phytoplasmas infect plants and are spread from plant to plant by insects, mainly leafhoppers that feed in the phloem tissue of the plant's leaves, the tissue conducting food material.

Pinnate
A leaf arrangement on a compound leaf where the leaflets are on each side of a common axis. An odd pinnate leaf has a single leaflet at the tip, giving it an odd number of leaflets. On legumes with three leaflets, if the terminal leaflet has a stalk, it is a pinnate leaf arrangement. Alfalfa, sweet clover and cicer milkvetch have odd pinnate leaf arrangements.

Pod
The fruiting body of legumes. The pod is the shell that contains the seed or seeds.

Pollinator
An insect that transfers pollen from the male anthers of a flower to the female stigma of a flower to accomplish fertilization of the flower for seed production. Insects are the most important pollinators of legumes. Grasses are commonly wind pollinated.

ppb
Parts per billion.

Procumbent
Trailing along the ground, without rooting.

Prostrate
To lie flat on the ground.

Pubescent
Covered with hair.

Raceme
A flower structure with each flower borne on a short stalk attached to a central stalk. The flower structure of alfalfa is a raceme.

Rachis
The central axis of a spike, raceme or pinnate leaf.

Regrowth
The new forage growth following a harvest of the initial top growth.

Re-seed
In this manual, re-seeding refers to plants setting seed, which can then shatter onto the ground and germinate to establish new seedlings.

Rhizobia
A genus of bacteria that lives symbiotically in legumes and fixes atmospheric nitrogen into a form the host plants can use. Different species of rhizobia are symbiotic with different legumes or legume groups.

Rhizome
A horizontal, underground stem, sometimes called a creeping root or rootstock. It can produce shoots and adventitious roots at the nodes and enable the plant to spread.

Rosette
A dense cluster of leaves on a very short, basal stem.

Rotational Grazing
A grazing practice where livestock graze a pasture for a short period of time followed by a period of rest that allows plants to recover and regrow. Two or more paddocks are used in a rotation.

Rudimentary
Not fully developed, may not be functional.

Salinity
A measure of salt concentration. See "dS/m."

Saturate
A saturated soil contains the maximum amount of moisture that it can hold.

Scabrous
Rough to the touch.

Scarify
To etch or scratch the hard seed coat of a seed (e.g. a cicer milkvetch seed) so that it will absorb water, enabling it to germinate. The process usually involves mechanical abrasion, but may be done chemically.

Sclerotia
A compact mass of hardened mycelium stored with reserve food material that in some fungi, such as ergot, becomes detached and remains dormant until conditions are favorable for growth.

Seed Bank
Un-germinated seeds present in the soil, generally from forage crops that have produced seed that has shattered onto the ground.

Seed Cover
Grasses have a lemma (outer seed cover) and palea (inner seed cover), which protect the seeds. They are sometimes called hulls.

Self-pollinated
Fertilization of the ovary of a plant with the pollen of the same plant.

Semi-arid
A climate where evaporation exceeds precipitation.

Senescence
The natural aging process of plant tissues and the ultimate deterioration of the plant tissue functions, i.e. as a leaf matures, it senesces and dries up.

Serrate
Having sharp teeth pointing forward.

Sessile
Having no stalk.

Sheath
In grasses, the sheath is the tubular, lower portion of the leaf that arises from a node and surrounds the stem. Opposing sheath margins may be separated (open), grown together (closed) or overlapping.

Shoot
See "tiller."

Simulated Grazing
To use machine harvesting to estimate the potential of pasture production, usually involving multiple cuttings per season.

Sod
Surface soil permeated by and held together by forage roots and/or rhizomes.

Sod Bound
Grass sod that is unproductive due to lack of available nitrogen. So called sod bound grass generally has a less well developed root system than one that is not sod bound.

Soil Texture
Relative proportions of soil, clay, silt and sand in combination comprises the texture of the soil.

Spike
A grass seed head where the spikelets are attached directly to the stem (the rachis) without a stalk, e.g. wheatgrasses, cereal wheat.

Spikelet
A secondary spike. In grasses, this is a structure with one or more florets that usually have a pair of glumes at the base where they are attached to the stem (rachis).

Stalk
A common term for a stem or similar structure that supports a plant part such as a flower, etc.

Stem
The plant structure that supports the branches and leaves of a plant.

Stipule
A leaf-like appendage at the base of a leaf stalk (at the leaf axil).

Stocking Period
The duration of time that livestock are grazing in a paddock or pasture.

Stocking Rate
The number of livestock per area of pasture, usually expressed as animals or animal units per hectare or acre, but may be expressed as hectares or acres per animal unit.

Stockpile
The accumulation of the growth of a forage crop that can then be grazed at another time during the year, e.g. ungrazed summer regrowth to be grazed in the fall or winter.

Stolon
A prostrate stem on or just below ground level, which produces shoots and roots at its nodes, enabling the plant to spread. White clover has stolons.

Stomata
Small openings in leaves that permit air exchange.

Swath Grazing
The practice of swathing a crop (generally a cereal crop) for grazing. These swaths are generally used to extend the grazing season in the fall or winter.

Symbiosis or Symbiotic Relationships
The association of two unlike organisms living together for the mutual benefit of each other. For example, legumes and rhizobia bacteria live together. The bacteria benefit by obtaining nutrients from the plant. The plant benefits from the nitrogen, which is fixed by the bacteria.

Subspecies
Subdivision or sub-member of a species, e.g. Flemish or Siberian alfalfa is a subspecies of the species alfalfa.

Tannin
Natural, soluble compounds called polyphenols that are found in leaves, seed, etc. of many forage plants. Tannins condense with proteins to form a substance that is insoluble and low in digestibility. Tannins may reduce or eliminate bloat when grazing legumes.

Taproot
A prominent central root from which branch roots or lateral roots develop.

Tetraploid
A plant with four sets of chromosomes in its cells.

Tiller
In grasses, a shoot forming at the base of the plant, which has a growing point that can produce leaves, stem, head and new buds. A grass plant may have several tillers.

Toothed
Leaf margins that are serrated or notched.

Total Digestible Nutrients (TDN)
The total digestibility of the organic components in the forage.

Trifoliate
Having three leaflets, e.g. clover.

Turf
Grass with its matted roots and rhizomes that hold the soil together.

Umbel
A flower structure where all flower stalks arise from a common point, e.g. birdsfoot trefoil flowers are umbels.

Utilization Year
The year when perennial forage is well enough established to first be harvested is the first utilization year.

Variegated
Made up of different colors. For example, some alfalfa varieties have flowers that are of variegated color.

Vernalization
The freezing or cold treatment required by some plants to flower and produce seed, e.g. winter wheat, fall rye.

Volatilization
The process where some fertilizers such as urea are converted to ammonia (NH_3) and evaporate into the atmosphere.

Warm-season Plants
A plant that grows best with warm temperatures (30 - 35° C). A 4 carbon acid is the first product leading to carbohydrate production during photosynthesis. C4 photosynthesis is more efficient than C3 photosynthesis (cool-season), but requires warmer temperatures. Corn is a warm-season crop.

Waterlogged
Saturated with water, greater than its water-holding capacity.

Watermark
A faint leaf mark, showing as a different color from the rest of the leaf, often V or crescent-shaped. Many of the common clovers, such as red and white clover, have a watermark on their leaves. It is useful in plant identification.

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Drawing Citations

Source citations for the drawings used in this book are listed here. The source is referenced by a letter, and the page is shown by the number.

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